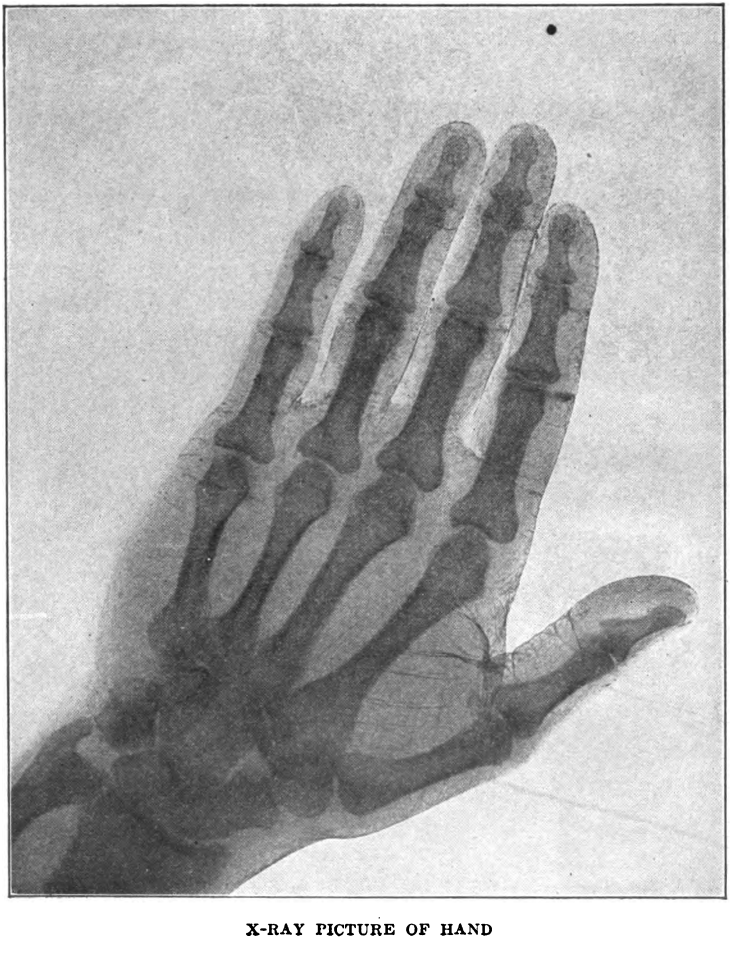
PHYSIOLOGY & HYGIENE

FOR YOUNG PEOPLE

EADIE



X-RAY PICTURE OF HAND

PHYSIOLOGY AND HYGIENE FOR YOUNG PEOPLE

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PREFACE

It is realized to-day, as perhaps never before, that our most precious possession is good health. There never was a time when greater effort was put forth to make it possible for children to grow up with strong, healthy bodies, and for grown people to live and do their work under healthful conditions. In the preparation of this book the authors have made it their chief aim to present the essential facts of personal, domestic, and public hygiene in such a way as to render the book an efficient ally of the forces that are working for healthy living.

A man entrusted with the care and running of a machine far less intricate than the human body is expected to know all its parts, and their relations to one another, before he is fitted to run the machine at its greatest efficiency. It is equally reasonable to expect that one is best fitted to care for his body, the machine with which he must do all his work, only when he knows its parts and the work that each should perform. Accordingly, in this book a sufficient amount of anatomy and physiology of the organs of the body is given to make their hygiene intelligible.

In order that the relation of the parts of the body may be best understood, these parts are considered under the three great functions by which life is maintained, viz., nutrition, movement,

irritability and control. The organs concerned in each function are thus studied in their relation to each other; and the function, instead of an isolated organ, forms the unit of study.

Before treating of a function as performed in the human body, this book shows how the same function is performed by plants and lower animals. This treatment furnishes the proper sequence to the nature study of the lower grades. It gives to pupils of the elementary schools a new and larger interest in living things; and, for those who go on to a high school, it affords a desirable introduction to the study of biology.

This book complies with the laws of those States which require that twenty-five per cent. of the text shall treat of "the nature and effects of alcoholic drinks and other narcotics." It is believed that the method of treatment herein employed will commend itself to the best judgment of those who are solicitous for the future welfare of the school children of to-day.

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PHYSIOLOGY AND HYGIENE FOR YOUNG PEOPLE

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PART I—LIVING THINGS AND FOOD

CHAPTER I

LIVING THINGS

It is often supposed that all living things can be divided into two distinct classes, plants and animals. Common animals are so different from common plants that it has always been easy to distinguish between them. A horse seems to us so different from a tree in whose shade it may be standing that we never think of putting them in the same class. Without any hesitation we say the horse is an animal and the tree is a plant.

But since living things came to be studied with the aid of a microscope, very small living things have been discovered which before were not known to exist. Some of these minute things resemble both plants and animals, and it is difficult to tell to which class they belong. In fact, it is impossible to fix upon any distinction between plants and animals by which all plants can be separated from all animals.

Although living things differ much in form, size, and appearance, yet they all do the same things, *i. e.*, perform the same *functions*, in order to keep alive. Plants and animals, both large

and small, keep themselves alive by performing the same functions, though not in the same way.

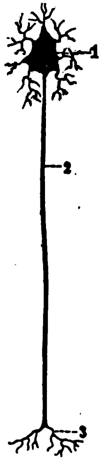
One of these functions is the taking of food into their bodies and using it up. A tree does not take in food in the same way that we do. Yet all living things, plants and animals alike, must take in and use up food in order to keep alive. In using up food, both plants and animals need to get oxygen from the air. They do not all get oxygen in the same way. We get it through our lungs, fish get it through their gills, common plants get it through their leaves; but plants and animals make the same use of oxygen in their bodies, no matter how they get it from the air.

Another function which plants and animals have in common is the power of movement. The animals that we know move about very freely. They need this power in order to secure food, to obtain shelter, and to protect themselves from enemies. Yet plants, as we shall see, make many movements, though their movements are slower and less noticeable than those of common animals.

Still another function that is common to both plants and animals is the power to adjust themselves more or less completely to the world around them. They have the power to seek those conditions of light, heat, moisture, etc., that are comfortable and helpful, and to avoid, to some extent, those conditions that are harmful or uncomfortable. The higher animals have nerves that greatly aid in doing this; but plants and lower animals that have no nerves perform the same function.

In your earlier study of physiology you learned something

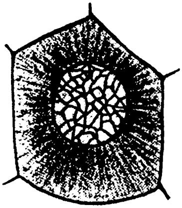
about the organs of the human body and the functions they perform in keeping the body alive. You probably formed the opinion that physiology treats only of the functions performed by the human body. But physiology treats of the functions performed by all living things, of which the human family is only a small part.



ONE KIND OF NERVE CELL

1. Nucleus
2. Fibre
3. Branches at end of fibre

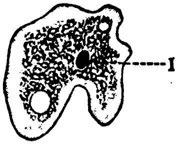
With this book you will continue your studies concerning the human body and how to take care of it. You will learn more fully about its different parts and how they work together to maintain life and to promote the health of the body. You will learn something also of the way in which other living things keep themselves alive. You will have a new interest in the plants and animals that you see about you when you realize that they maintain their lives by performing the same functions as are performed in the human body.



ONE KIND OF CELL SHOWING NUCLEUS WITHIN THE PROTOPLASM

Cells.—Living things, whether plants or animals, are made up of small, living particles called cells. The word cell is often used to mean a space surrounded by walls, as when we speak of a cell of a prison or a cell of a honey-comb. The cells of most plants have walls, which enclose the living matter. Some animal cells have walls, but others have none; they are just little naked specks of living material.

Cells vary greatly in size. Most cells cannot be seen without a microscope. They usually vary from $\frac{1}{300}$ to $\frac{1}{1000}$ of an inch in diameter. The natural form of a cell is spherical, like a ball; but when cells are crowded together they assume different shapes.



AN AMŒBA
1. Nucleus

In a general way, a cell somewhat resembles in appearance a tiny bit of transparent jelly, in which there is a smaller, denser part. The jelly-like, living substance of a cell is colorless and is called *protoplasm*. The work of the cell is done by the protoplasm, and, in fact, all the work done in the body is done by the protoplasm of its different cells. The smaller, denser part in the interior of a cell is called the *nucleus*. A nucleus appears to be necessary to the life of every cell.

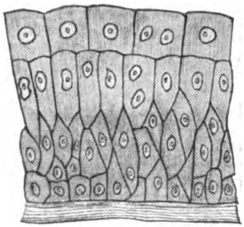
The substance of a living cell is always changing. It is constantly wearing out, and new matter is being made to take the place of what is worn out. A worn-out particle of a cell is cast off as waste matter, but the cell repairs itself by taking in food and using it to renew its own body. A living cell, then, is not composed of exactly the same material from day to day. Particles of the cell die and are replaced by new particles, but the cell as a whole continues to live.

Amœba.—In the lowest kinds of plants and animals the whole body consists of one cell. The amœba, which lives in stagnant water, is a common example of a one-celled animal. Although it is so small that it can be seen only with a microscope, it is a complete animal, for it can move itself about and assume different

shapes; it can take food into its body and digest it; it can take in oxygen and give out waste matter; and, finally, when full-grown, it can divide through the centre and form two amœbas like the original.

The higher kinds of animals and plants consist of millions of cells. Each of these cells, acting separately, takes in food, and grows. When it is mature, it may divide and produce other cells. Cells that are similar and fitted for the same kind of work are arranged in groups, or masses, called *tissues*. As the wall of a house is made up of bricks held together by cement, so the various tissues are built up of cells held together by cementing material. The bricks in a wall cannot make the cement that holds them together, but the living cells of the tissues make their own cementing material.

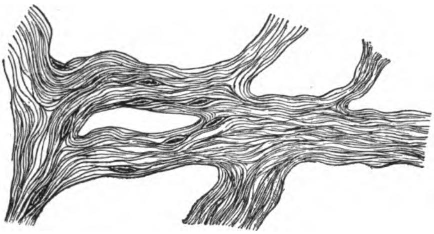
Animal tissues.—In the body of a higher animal there are different kinds of tissues, which are joined so as to make up the entire body.



ONE KIND OF EPITHELIUM

Epithelial tissue.—The simplest kind of tissue is *epithelial* tissue, or *epithelium,* composed of cells held together by a very small amount of cementing material. As a rule, epithelium is spread out into a thin membrane. It is used to cover a surface, and to line the cavity of a hollow organ. The skin of the human body has a thin covering of epithelium, and epithelium forms a thin lining for the lips, throat, stomach, intestine, and other parts.

Connective tissue.—This kind of tissue connects and binds together the cells, tissues, and parts, so as to make one whole body. One peculiarity of connective tissues is that they are made up of a small number of cells and a very large amount of cementing, or intercellular material, that is, material between the cells. There are several kinds of connective tissue, which differ greatly in appearance. Among these are included cartilage, bone, blood, and fat.



ONE KIND OF CONNECTIVE TISSUE

In some varieties of connective tissue the intercellular material is in the form of thin sheets and fibres. In bone, the intercellular material is largely composed of lime, which makes the bones firm and hard. In blood, the intercellular material is a fluid. Fatty tissue is found in larger or smaller quantity in almost all parts of the body. It consists of connective tissue in which the cells are distended and filled with fat, which is fluid at the ordinary temperature of the body.

Muscle tissue.—In animals whose bodies are composed of different kinds of tissue each tissue has its special work. The tissue that has the special work of producing movement is muscle. Muscle in a body does not consist of one mass, but of different bundles of tissue, each bundle being called a muscle. When muscle tissue is examined under a microscope, it is seen to be

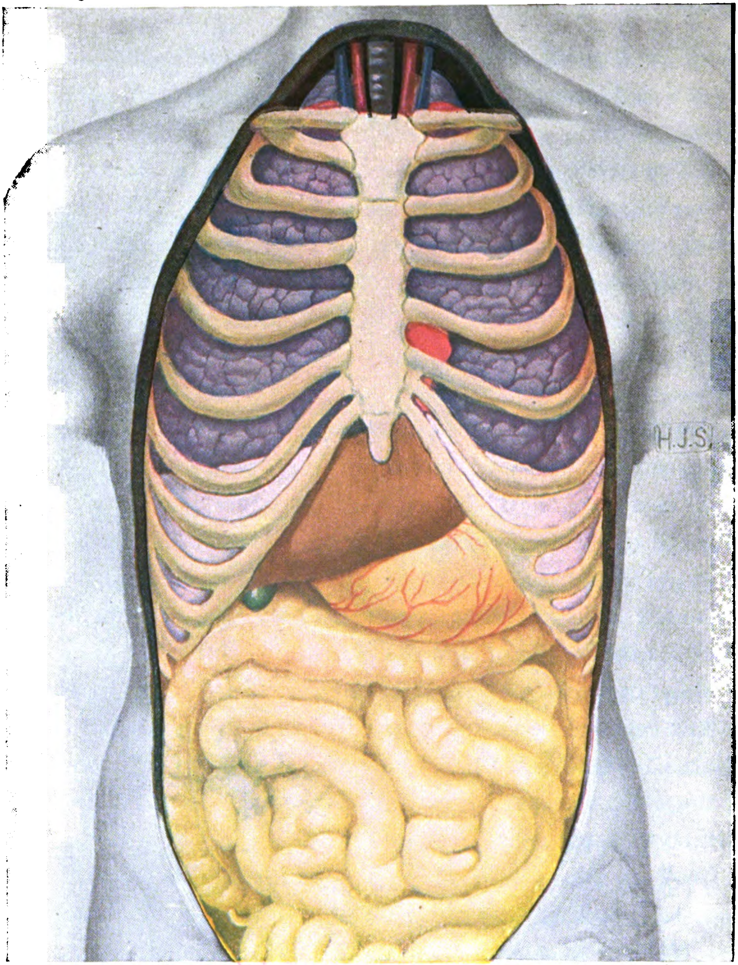
made up of small cells that are elongated into threadlike structures called fibres. These fibres are held together by connective tissue.

Nerve tissue.—Still another kind of tissue is *nerve* tissue. It is composed of cells that are supported and held together by a special kind of connective tissue. Extending from the cells are fine threads, or prolongations of the cells. Some of these prolongations form nerve fibres, which are bound together by connective tissue into strands and form the nerves.

Organs.—Tissues are grouped together to form organs. Each organ has a special work to do which is called its function. The heart is an organ. It is composed of different kinds of tissue grouped together, and its function is to force blood through the body. The stomach is an organ whose function is to digest food. Although each organ has a special work to do, yet it does that work for the benefit of all parts of the body.

Many organs are very delicate, and so we find them placed in hollow cases of bone, called cavities, to keep them from being injured. The brain, which is the organ of the mind, is shut up in the skull, and many important organs are placed in the large cavities of the trunk.

Look at the picture on page 8, and you will see the ribs and the breastbone, which protect the organs in the chest cavity. Behind the ribs are the organs called lungs. In the centre of the neck you can see the tube called the windpipe, which extends upward from the lungs. The air that you breathe passes



A VIEW OF THE INSIDE OF THE TRUNK

(See Appendix for Key)

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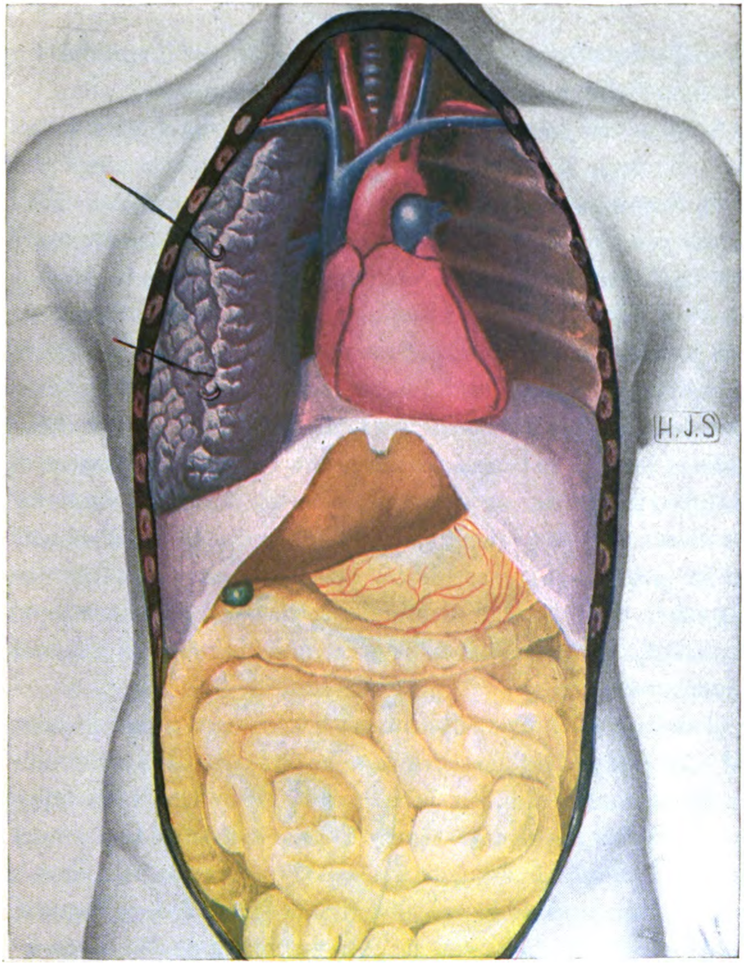


ANOTHER VIEW OF THE INSIDE OF THE TRUNK

(See Appendix for Key)

through the windpipe into the lungs. Both the lungs and the windpipe have been colored purple in the picture.

Look at the picture on page 9. The ribs have been taken off, one lung has been taken out, and the other lung has been drawn back so that you may see the cavity of the chest. There you see the heart, which is colored red. Above the heart are blood tubes, colored red and blue, that go from it to other parts of the body. Just under the heart and lungs you can see the partition, called the *diaphragm,* that separates the chest from the abdomen. Below the diaphragm is the organ called the liver. Below the liver is the stomach. In the picture the liver has been colored brown, and the stomach yellow, with red lines over it. A tube called the esophagus goes from the mouth down to the stomach. It is just behind the windpipe, and so cannot be shown in the picture. It is through this tube that food passes from the mouth to the stomach. Below the stomach, neatly folded and curled up, is the intestine, in which the process of digestion is completed.

The human body.—The human body is not a mere collection of cells grouped together in a complex system. It is a carefully designed and beautifully furnished home in which the mind dwells. The health and vigor of the mind depend very much upon the health and vigor of the body. If we would have a strong, pure, and noble mind, we should give it a clean, healthy, and vigorous body to dwell in. But we cannot do this unless we know something about the body and the laws of health that govern it. If we are ignorant about these matters we are likely

to do many things that injure and weaken the body and keep the mind from developing as it should. There are three important branches under which we can study the body. These branches are *anatomy*, *physiology*, and *hygiene*.

From the study of anatomy we learn the shape, size, and location of the various organs and tissues of the body.

From the study of physiology we learn the uses, *i. e.*, the functions, of the different organs and parts of the body.

From the study of hygiene we learn how to take care of the body and keep it in health.

Since good health is the most precious possession we can have, it becomes the duty of every one to observe the rules of living that tend to promote good health, and to refrain from whatever tends to injure it. A world-wide experience shows that one of the greatest causes of impaired health and bodily suffering is the use of alcoholic liquors, tobacco, and other narcotics. Because of this well-known tendency of alcoholic liquors to impair health and to unfit the body for doing its best work, many business men require their employees to refrain from the use of such liquors. This is especially true of employees in responsible positions. Many athletes and professional men, too, refrain from the use of alcoholic liquors in order that they may keep their bodies in the best condition for performing exacting duties that call for the greatest endurance or the highest skill. Statements to this effect, such as the following, are easily obtainable in large numbers.

WORCESTER ELECTRIC CONTRACT COMPANY

WORCESTER, MASS., *January* 25, 1909.

Dear Sir:—I am opposed to the use of alcoholic liquors in any amount by my employees, at any time, and will not take into my employ such persons as I know occasionally or frequently use them.

Very truly,

ROGER T. MORRIS,

President and Manager.

NEW YORK, *January* 23, 1909.

Dear Sir:—In reply to yours of January 4th, I will say that I have never used alcoholic liquors, and would strongly advise against the use of the same in athletic work.

Very truly yours,

CHRISTY MATHEWSON,

New York Base-ball Team, National League.

Sir Frederick Treves, a distinguished surgeon of London, England, said in a recent address : "The man who works on even a moderate amount of alcohol is not at his best. The use of alcohol is absolutely inconsistent with a surgeon's work, or with any work demanding quick, alert judgment."

SUMMARY

1. Plants and animals keep themselves alive by performing the same functions.
2. One of these functions is to take in food and oxygen and use them up.
3. Another function is movement.
4. The third of these functions is the seeking of conditions that are helpful, and the avoiding, as far as possible, of conditions that are hurtful.
5. Plants and animals are made up of one or more cells.
6. Two important parts of a cell are the protoplasm and the nucleus.

7. The substance of a living cell is constantly wearing out, but the cell replaces its worn-out matter.

8. Similar cells are massed together to form tissues.

9. Tissues are grouped together to form organs.

10. Epithelial tissue is used to cover a surface, and to line the cavity of a hollow organ.

11. Connective tissue binds together cells, tissues, and organs to form one body.

12. The work that an organ or part of the body does, is called its function.

13. The body is a home for the mind to dwell in.

14. The study of the body includes its anatomy, its physiology, and its hygiene.

CHAPTER II

KINDS OF FOOD AND THEIR USES

Eating.—If you should travel about the earth and visit different zones, you would find that the people living in different climates eat different kinds of food. In the frozen north, the Eskimo's favorite food is blubber and other fat. In the sunny tropics, nobody can eat blubber; but everybody likes fruit. In countries that are neither very hot nor very cold, the inhabitants prefer a mixed diet of meat, bread and butter, fruit and vegetables. But though diet varies in different climates, the food that is eaten in each supplies the material that is needed to support life.

Making new tissue and repairing old.—Your body is not made up of the same particles from day to day. The material composing the cells of its tissues is constantly wearing out. Tiny worn-out particles of these cells are cast off as waste matter and are replaced by new material. In this way almost every part of your body is changed by slow degrees. The change, however, is so gradual and the repair is so complete that no difference can be seen in your appearance except after a considerable time. The new particles are made out of material supplied by the food that you eat. Without food the building-up and repairing stop, while the wearing-out goes on more and

more rapidly. When a man is starving, he becomes lighter every day because his tissues are wasting away and he is taking no food to make new tissue.

Growth of the body.—In childhood and in youth food is needed not only for the repair of the tissues, but for their growth. You are larger now than you were two years ago, and two years hence you will probably be larger than you are now.

The rate of growth varies at different ages and in different children. It declines steadily after about the sixteenth year, and usually ceases about the twenty-fifth year.

Plain wholesome food, pure drinking water, exercise in the open air, regular and sufficient sleep are necessary for the healthy growth of the body.

Children sometimes have what are called growing pains in the arms and legs. These pains are not due to growth. Growth is painless. Pains in the arms and legs of young persons are a sign of disease, and should be regarded as nature's warning that something is wrong. The advice of a physician should be obtained without delay in all such cases.

Bodily heat.—The proper bodily temperature is 98.6° F. If it gets much lower than that, the body suffers just as surely as a plant suffers in the frost. Yet heat is constantly leaving the body, and we should grow too cold unless a fresh supply was furnished. This supply must come from food.

The power to work.—Besides being used for repair, growth, and bodily heat, food is needed to produce the power to work, or even to move.

Food substances.—No one kind of food can supply all the different materials that are needed to build up the body, and to furnish it with heat and the power to work. Some food substances furnish chiefly building material, some furnish chiefly heat and the power to work. There are four kinds of food substances: (1) *Proteids,* (2) *Carbohydrates,* (3) *Fats,* (4) *Salts and Water.* All of them, in varying amounts, are necessary to keep the human body in its best condition; and the best diet is a "balanced diet" from which a person can get the four food substances in the quantities that he needs. All of the many articles of diet on our tables are made up of one or more of these four substances.

Proteids.—The proteids are sometimes called animal foods, because lean meat consists largely of proteid, but cereals and some other vegetables also contain proteid. Carbon, oxygen, hydrogen, and nitrogen are all found in proteids. Proteids have been called nitrogenous food because they supply us with nitrogen. Another name for proteids is tissue foods; still another is flesh formers. Without proteid food there can be no building up or repairing of the tissues.

Albumen.—There are four principal kinds of proteids. You probably eat some of each kind every day. For example, the white of egg is a form of proteid. It is called albumen, and is an important article of diet. It is proteid in a concentrated form. The yolk, too, contains proteid matter, and is rich in fat. Eggs contain also a small amount of mineral matter and a trace of sugar.

Myosin.—If you were asked if you had ever eaten myosin, you would probably answer no; yet you eat it every time that you eat lean meat. Lean meat consists chiefly of muscle, and myosin is the most important part of muscle.

Lean meat is the most concentrated and most easily digested of proteid foods, and therefore one of our most valuable articles of diet for building up the body and for repairing its tissues.

Gluten.—Put some flour into a little muslin bag and pour water on it for several minutes. You will find that a gummy mass is left. That gummy mass is another form of proteid, and is called gluten. You eat gluten in bread, cake, and other articles of diet made from flour.

Caseinogen.—This is one form of proteid in milk. Besides caseinogen, milk contains water, fat, milk-sugar, salts, and albumen; in other words, all the materials required for the nourishment of the human body. The proteids in milk build up the body and keep it in repair, while the fats and milk-sugar furnish fuel to give heat and power to do work. Milk is a perfect food for infants; but, for those who are older, it contains too much water and not enough proteid, sugar, and fats to be used as the sole article of diet in ordinary conditions of health.

The curdling of milk.—The lining of the stomach in many animals, and especially in the young calf, contains a ferment called rennet. Rennet has long been used to curdle milk in making cheese. This ferment acts on the caseinogen and changes it into casein. The casein, while being formed in the

milk, entangles the fat globules in its meshes; and these together form the soft, semi-solid mass called the curd. The curd when pressed and dried forms cheese. The watery part that remains is called whey. It consists of a small amount of sugar, salts, and albumen, and a large amount of water.

The souring of milk.—When milk is allowed to stand, germs act on the sugar that it contains and change the sugar into an acid which gives the milk a sour taste. The acid also changes the caseinogen into a soft curd.

Contamination of milk.—Milk readily absorbs odors from decaying matters, from vegetables such as onions, and from other substances that have strong odors. These give rise to a disagreeable taste in the milk.

The germs of such diseases as typhoid fever, scarlet fever, diphtheria, and tuberculosis may get into milk, and thus spread these diseases, if it is handled by persons that are recovering from, or have been exposed to, one of them. Another way these diseases are sometimes spread is by washing cans, pails, or other milk vessels in water that contains disease germs.

Milk, like all other food, must be kept clean in order to be pure and wholesome. The stables, cows, and those who milk them should be clean. Pails, cans, and bottles used to hold milk should be thoroughly washed with lukewarm water and then scalded with pure boiling water each time they are used. Milk should be kept in a clean, dry, well-ventilated room that is free from strong odors, and at a temperature not higher than 45° F.

Destroying germs in milk.—When milk is uncovered, germs of different kinds, or bacteria as they are also called, get into it with dust from the air. During the process of milking, a few bacteria will get into the milk even when the stables, cows, and those that milk them are as clean as possible. But a very much greater number of bacteria get into milk, along with dust, when the stables, cows, and milkers are not clean. These bacteria increase in number very rapidly if the milk is allowed to remain warm. If, however, it is soon cooled down and kept at a temperature not higher than 45° F., the bacteria are unable to increase in number for a day or two.

The bacteria in milk may be destroyed by heating the milk. If the temperature is not raised to the boiling point, the milk is said to be pasteurized. In the "Year-book of the Department of Agriculture" for 1907, issued by the Government of the United States, the following directions are given for pasteurizing milk: "Milk may be efficiently pasteurized in the household by setting the bottle of milk in a vessel containing water, and heating the water until the milk reaches a temperature of about 150°. It may then be removed from the stove and allowed to stand for twenty to twenty-five minutes. The temperature of the water will be above that of the milk, and while it slowly cools the milk will be thoroughly heated. It should then be chilled at once and kept cold until used."

When milk is thus pasteurized, nearly all, if not all, the bacteria it contains are killed. But in the milk there are still spores, which correspond to the seeds of larger plants, and

these may produce other bacteria. If the milk is now cooled to about 45° F., and kept cool, the spores in it cannot produce bacteria. Milk for infants should not be kept warm during the night.

The bacteria in milk may be destroyed by simply heating it until it boils. But when milk is heated above 167° F. it loses some of its food value. If milk is boiled freely, it is changed considerably, and may cause serious intestinal troubles, especially in children, if it is used for some time.

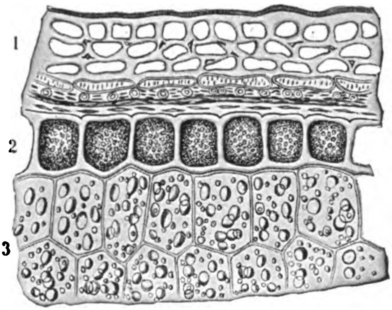
Carbohydrates.—Such a word as carbohydrates does not mean much to you, but you are as well acquainted with examples of carbohydrates as with the different proteids. Carbohydrates is but another name for starch and sugar. They contain carbon, oxygen, and hydrogen, but no nitrogen. Carbohydrate food furnishes heat and the power to work, and is sometimes called fuel food.

Starch.—Starch forms a large part of all cereals, such as wheat, rye, corn, barley, rice, and oats. Potatoes contain a large amount of starch, and it is contained also in peas and beans, in arrowroot, tapioca, and sago.

Starch is made up of tiny granules. When corn starch is rubbed between the fingers these little bodies have a gritty feeling. The form of the granules is different in each variety of starch, so that the different varieties may be distinguished from one another by looking at the granules with a microscope.

Bread.—In this country bread is usually made from wheat

flour. A grain of wheat is composed largely of starch and the proteid substance called gluten. The picture shows a section of a grain of wheat magnified. The outer layers are the bran, which resembles woody fibre. The row of large dark cells beneath this is composed of gluten. Beneath the gluten are cells containing small round starch granules.



SECTION OF GRAIN OF WHEAT

1. Bran. 2. Gluten cells. 3. Cells containing grains of starch

When wheat is ground the outside layer of bran is peeled off and removed. Wheat flour consists of a large amount of starch and a much smaller amount of gluten. Bread is poor in fat. This deficiency is usually made good by the use of butter, which renders the bread more palatable.

Meal, made from corn or oats, also contains much starch, a considerable amount of proteid matter, and some fat.

Peas and beans.—Peas and beans contain starch and proteids. They are not so easily digested as meat or bread, yet on account of their low cost and the amount of food substance in them, they may often be used to advantage in the place of higher-priced food.

Sugar.—The ordinary sugar that we use for sweetening our food is called cane-sugar because it was first obtained from

sugar-cane. It is found also in the juice of many other plants. At present it is commonly made from sugar beets. It is especially useful as a food in times of great exertion, because, being rapidly digested, it quickly reaches the muscles and supplies them with material for producing muscular power.

The amount of sugar that may be eaten without bad effects depends much on the amount of active exercise that is taken. A person doing hard work in the open air can eat a good deal of sugar, while the same quantity would cause indigestion if taken when one is living an indoor life and taking little exercise.

Milk contains from four to five per cent. of a form of sugar called milk-sugar. It is said to be the most digestible sugar for infants.

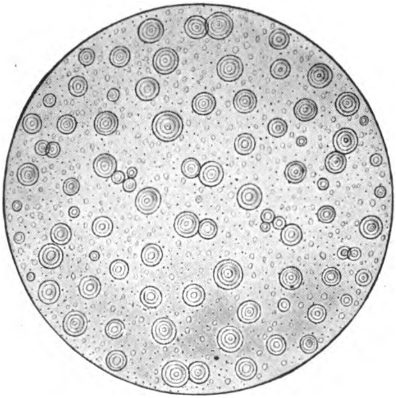
Another variety of sugar is grape-sugar. It may be seen as yellowish granules in dried raisins, and is found in small quantities in other fruits. It is not so sweet as cane-sugar, and differs from it in appearance.

Starch and sugar are closely related. The starch in fruits is changed into sugar as they ripen, and the starch in the food that we eat is changed into sugar as the food is digested.

Fats.—Fats contain exactly the same materials as do the carbohydrates, viz., carbon, hydrogen, and oxygen—but in different proportions. Fats are useful chiefly to furnish heat and power to work, and are found in animal food, such as meats, fish, and butter. They are abundant, too, in some vegetable products, such as olives and cotton-seed, and are contained in considerable quantities in such cereals as oats

and corn. In very cold countries the fats are valuable food-stuffs, because they can furnish an abundant supply of heat. The reason that the Eskimo would rather eat blubber than fruit is because the blubber supplies him with fat, and fruit does not.

Butter.—The fat in fresh milk is in the form of very small globules, which are evenly distributed throughout the milk. If it is allowed to stand for some hours, these globules and some milk adhering to them rise to the surface because the fat is lighter than the rest of the milk. The part that rises to the surface is called cream. When cream that is cool is agitated in a churn, the little globules unite and form a solid mass called butter. The liquid that remains after the butter is removed is called buttermilk. Butter is an important article of diet, for it furnishes the chief source of fat in the food of children and many grown people. Fat meat is also a valuable form of food, but many persons do not like it so well as butter.



ROUND PARTICLES OF FAT IN A DROP OF MILK SEEN UNDER A MICROSCOPE

Nuts.—Nuts contain proteid, some starch, and a variable amount of fat. The cocoanut, chestnut, almond, and English

walnut are the varieties that contain the most nutriment, but some persons cannot digest them. Their chief value is to afford variety in the diet.

Salts.—Salts are mineral food. You are familiar with the word salt as the name of common table salt. But this is only one kind of salt. There are, also, salts of lime, potash, phosphorus, iron, and many others. Some salts are used to make bone tissue. Other salts cannot be used to build up tissue, or to furnish heat and muscular power, yet they help us to digest the articles of food that serve these purposes. The mineral part of bones consists largely of salts of lime.

Common table salt is an important article of food. It is found in considerable quantities in the blood and in all the other fluids of the body. It would not be possible to live without it as an article of diet. It stimulates the appetite and furnishes material required for the secretion of gastric juice, an important digestive juice of the stomach. Too much salt in the food produces thirst. Almost every kind of food that we eat contains some salt, so that we obtain a considerable supply of it in addition to what we add to our food.

Mr. Henry W. Nevinson, in writing in *Harper's Magazine*, of that section of Africa called "The Hungry Country," says:

"All living creatures in this region are crazy for salt. The natives will sell almost anything for it, and a pinch of it is a greater treat to a child than a whole bride-cake would be in England." Even the bees and the butterflies seek salt. Mr. Nevinson wrapped a bag of salt in tar paper and put it on the

ground to see what the bees would do to it. In twenty minutes it was densely covered with bees. A little salt on a damp rag will attract butterflies until "the rag will be a blaze of colors, unless the bees come and drive the butterflies off."

Green vegetables.—Green vegetables, such as cabbage, carrots, turnips, string beans, green peas, and the like contain much less carbohydrates and proteids than cereals do. But they are useful on account of the salts that they contain, and they furnish a pleasant variety in diet.

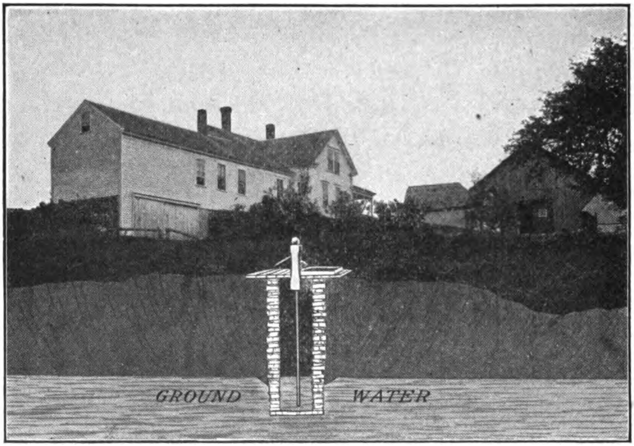
Fruits in great variety are used for food. Their chief nourishing substances are the sugar and salts that they contain.

Water.—Water, like salt, is a mineral food. Our blood, bones, muscles, and all other organs contain water. It is absolutely necessary not only to health, but to life. You could live without any other kind of food longer than without water. Most articles of diet contain it; some contain it in large quantities. For instance, beef is one-half water, potatoes are three-fourths water, and milk is about nine-tenths water. All solid food contains some water, and fluid food is largely composed of it.

Since water is so necessary to mankind, a plentiful supply of pure drinking water is very important. Drinking water is usually taken from springs, wells, rivers, or lakes. Water that contains decaying animal or vegetable matter is not fit for use. Hence, water from shallow wells, or from wells near drains, farmyards, or cesspools is wholly unfit for drinking.

The germs of such diseases as typhoid fever, cholera, and

dysentery are easily conveyed in drinking water. Every one living near the banks of streams or lakes from which drinking water is obtained should be extremely careful to preserve the purity of the water, and should never, under any circumstances,



THE SURFACE SHOULD NOT SLOPE TOWARD THE WELL

allow anything to be put into the water that can possibly contaminate it. All wells should be fenced off, so that cattle and other domestic animals and fowls may be kept at a considerable distance from them. The site for a well should be chosen carefully, and should be a raised spot, so that the surface water will drain away from the well and not toward it.

Whenever there is even a suspicion that the drinking water is not pure it should be boiled. The germs of disease are destroyed by boiling.

Tea and coffee.—The value of tea and coffee is in their flavor and in their power mildly to stimulate the nervous system. Both are merely flavored water. Both furnish a means of relieving thirst and of introducing a needful amount of fluid into the body. Tea, when properly made and taken in reasonable quantity, may be considered healthful for many people, but it does not appear to be suitable to all. Excessive tea drinking, or the drinking of tea that is too strong, hinders digestion and disturbs the nervous system.

Coffee should be made from newly roasted and ground beans. If the beans are ground too long before being used, much of the flavor is lost. The action of coffee is much like that of tea. There are many persons that prefer coffee because it aids digestion and affects them in every way more agreeably than tea does. Excessive quantities are harmful.

Cocoa and chocolate.—Cocoa and chocolate are both prepared from the cacao bean. They contain some food substance in the form of fat, proteid, and starch. When properly prepared they are wholesome beverages, and furnish desirable hot drinks for children and young people. When tea, coffee, cocoa, or chocolate is made for children it should be made weaker and more milk should be added than when it is made for older persons.

The railroads and alcoholic liquors.—The railroad companies of this country have for a long time had strict rules against the use of alcoholic liquors by their employees while on duty; and many companies give a preference, in filling positions,

to men who are known not to drink such liquors. The purpose of these rules is to make the operating of the roads as safe as possible.

It is evident from the rules quoted below that railroad companies, at least, consider that the use of alcoholic liquors unfits employees for their best service.

THE DELAWARE, LACKAWANNA & WESTERN RAILROAD CO.

The use of intoxicating drinks on the road or about the premises of the Company is strictly forbidden. No one will be employed or continued in employment who is known to be in the habit of drinking intoxicating liquor.

E. G. RUSSELL,
General Superintendent.

BOSTON & MAINE RAILROAD

Intoxication, or the habitual use of intoxicating liquors by employees, is strictly forbidden, and will be sufficient cause for dismissal from the service of the road. Total abstinence in this particular is necessary to safety in operating the road, and employees in any capacity who frequent gambling houses or places where liquor is sold, will not be retained in the service.

D. W. SANBORN,
General Superintendent.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

The use of intoxicating drinks has proven a most fruitful source of trouble to railways as well as to individuals. The Company will exercise the most rigid scrutiny in reference to the habits of employees in this respect, and any employee who has been dismissed on this account will not be re-employed. Drinking when on duty

or frequenting saloons will not be tolerated, and preference will be given to those who do not drink at all.

H. R. WILLIAMS,
General Manager.

SOUTHERN PACIFIC COMPANY

The use of intoxicants by employees while on duty is prohibited. Their use, or the frequenting of places where they are sold, is sufficient cause for dismissal.

ROCK ISLAND LINES

LITTLE ROCK, ARK., *January* 11, 1909.

Dear Sir:—Replying to yours of January 5th, our rules are as follows:

"The use of intoxicants by employees while on duty is prohibited. Their habitual use, or the frequenting of places where they are sold, is sufficient cause for dismissal."

"The use of tobacco by employees when on duty in or about passenger stations, or on passenger cars, is prohibited."

In their applications for employment, applicants are requested to state whether or not they smoke cigarettes; if so, we do not employ them. We also forbid the smoking of cigarettes by the employees of any department while on duty.

Trusting this information may be of some benefit to you, I remain,

Yours truly,

F. J. EASLEY,
Superintendent.

SUMMARY

1. Food substances consist of proteids, carbohydrates, fats, water, and salts.

2. The proteids are needed to replace worn-out particles of the cells, and to build up new tissue.

3. Some of the common proteids are albumen, myosin, gluten, and caseinogen.

4. To prevent bacteria from increasing in number in milk, it should be cooled as soon as possible to 45° F., and kept cool until it is used.

5. To destroy bacteria in milk it should be kept at 160° F. for twenty minutes. It should then be kept cool to prevent spores from producing other bacteria.

6. Carbohydrates consist of starch and sugar.

7. They furnish material for producing heat and power to work.

8. Fats, too, are used in the body to produce heat and power to work.

9. When cream is churned the little globules of fat it contains unite and form butter.

10. The mineral part of bone, which makes it hard and firm, consists chiefly of salts of lime.

11. Water may convey disease germs.

12. These germs may be destroyed by boiling the water.

CHAPTER III

COOKING

Why we cook our food.—One reason why we cook food is to make it more digestible. While meat is cooking, the connective tissue, which binds the muscle fibres together, is softened and dissolved so that the fibres fall asunder and can be more easily digested. When lumps of meat are swallowed, gastric juice can attack and digest the fibres on the surface only, for it cannot reach those in the centre. The central part of a tough piece of meat that is swallowed without being thoroughly masticated is digested slowly and with difficulty, or may remain undigested. The granules of starch in cereals are contained in tough envelopes of a material called cellulose. During the process of cooking the starch granules swell up and burst their envelopes. For this reason, cooked starch is digested more completely and more quickly than raw starch.

Another reason for cooking food is to destroy parasites and germs that may be present in the raw food. These are destroyed when the temperature is raised to the boiling point.

The cooking of food develops a flavor in it so that it will taste better. The taste or even the smell of a savory dish is sufficient to excite a flow of saliva and gastric juice, and thus aid diges-

tion; whereas unsavory or carelessly prepared food has the opposite effect.

The methods of cooking in common use are boiling, stewing, roasting, baking, broiling, frying, and steaming.

Boiling.—When meat is put into water that is boiling, the albumen on the surface is seared, or hardened, in a few minutes. A thin layer is thus formed on the surface.

Within this seared layer the juices are held imprisoned so that, even after the meat has been finally cooked through and through, it remains juicy, has lost but little of its nutriment, and has a fine flavor. After boiling for ten minutes the temperature of the water should fall slightly below the boiling point. If the water is kept at the boiling point for an hour or more the albumen in the inside will be overcooked and the meat will be tough and stringy. The temperature, however, should be only a little below the boiling point, or the inside of the meat will not be thoroughly cooked.

Stewing.—Stewing differs from boiling. The object in boiling is to retain the juices in the meat. The object in stewing is to cook the meat at a temperature below the boiling point, so as to allow the juices to pass out into the water in which the meat is cooked. The best temperature for stewing is 180° F.

If the meat to be stewed is cut up into small pieces the juices pass out more readily. The flavor may be changed by adding barley or sliced vegetables. When the solid portions of the meat and vegetables are eaten along with the liquid, the stew forms a wholesome, nourishing, and economical food.

Soup.—Meat soups are made by cooking meat at a low temperature for five or six hours. The cheaper parts of meat are as well suited for making soups as the more expensive cuts. The food value is increased by cooking fragments of bone along with the meat. By long-continued cooking at a low temperature the connective tissue of the meat is changed into gelatin and is gradually dissolved out into the water, along with the valuable juices, salts, and flavoring matter. Vegetables may be used alone for making soup, or they may be added to meat.

Soup, as a rule, contains only a small amount of nourishment, but it increases the flow of gastric juice in the stomach. In this way it increases the appetite and aids in the digestion of the solid parts of the meal.

Beef tea.—Beef tea and other similar extracts of meat contain only a small amount of food. They are valuable chiefly in the diet of invalids and others that are unable to take the usual amount of solid food.

In making beef tea the meat should be cut up into very small pieces and put into cold water. One pound of lean meat is enough for one pint of water. The meat should stand in cold water for about an hour, and then be heated slowly in a double boiler, with occasional stirring. During this time the temperature of the mixture should remain a little below 167° F., for, at this heat, proteid coagulates. After the mixture has been cooking at a low temperature for an hour, it should be heated to the boiling point and then removed from the fire. The tea should

be poured from the meat and allowed to cool. When it is cool, the fat on the top should be removed. The tea will then consist of a brown liquid at the top and small particles of coagulated proteid below. If beef tea is boiled for some time the coagulated proteid becomes hard and difficult to digest. When the tea is boiled a scum is formed of coagulated proteid; and, if this is thrown away, the remaining part is of little value.

Baking and roasting.—The old way, and by far the best way, to roast food was to hang it on a spit over an open fire. In some countries this method is still employed for roasting, but it is not in use in the United States. What we call roasting is really baking. What we call roast beef is really baked beef. Baked beef is cooked in an oven instead of over the open fire. The oven should be very hot when the roast is put into it. The outer layers of proteid then form a coating on the surface, which keeps almost all the natural juices of the meat from passing out. A little of the juice, however, always escapes, and this, together with the melted fat, forms the gravy, which is very nutritious and may be used for basting the roast so as to prevent drying or burning on the surface. After ten or fifteen minutes the heat of the oven may be slightly reduced so as to avoid charring the surface of the roast. Meat, bread, cake, and many kinds of vegetables can be baked.

In making bread, flour is mixed with yeast, salt, and water, and kneaded into a dough. If the dough is kept warm, little ferments in the flour act on the starch, which is, in part, changed to sugar. The yeast then attacks the sugar, and by a process

called fermentation, forms alcohol and a gas known as carbon dioxide. Gluten is sticky when moist and prevents the carbon dioxide from passing off as soon as it is formed. This gas, in its efforts to escape, forms bubbles and causes the bread, or dough, to rise and become light and spongy. It is then baked in a hot oven. The heat destroys the yeast, stops fermentation, and drives off all the alcohol. Baking powder may be used instead of yeast.

Broiling.—Broiling is a method of cooking meat by bringing its surfaces near a glowing fire. Much less time is required for broiling than for roasting or boiling. Care should be taken to have the fire very hot, and the surface of the meat should be placed near the fire.

Steaks or chops intended for broiling should be cut thick. Thin pieces of meat become dry, shrivelled, and tough by broiling; but thick slices, when properly broiled over a very hot fire, are juicy, tender, and palatable.

Frying.—Frying is a method of cooking in melted fat. The fat should be hot enough to harden the outer layer quickly and form a crust on the surface, so as to prevent the escape of the juices and to keep the fat from soaking in. Food that has soaked in much fat is very indigestible. The best frying is done by having the fat very hot and deep enough to cover the food, so that it becomes crusted all over at once. Then the fat cannot soak into it.

Steaming.—Steaming is suitable for puddings, cereals, and many green vegetables. The cooking is done in a steamer or

double-boiler, by the heat of steam that surrounds the vessel holding the food.

What to eat.—As milk is composed of proteid, sugar, fat, salts, and water, it is a complete mixed diet. The proportion of water, however, is too great to allow it to be the sole food of an adult, but it is one of the best articles of diet for infants and children. Cream, too, is nourishing. It may be mixed with milk and used with oatmeal and other cereals, with bread, and with mashed potatoes, or in other ways.

Children require fat in their food. They do not, as a rule, digest fat meat as well as grown people do. Butter is a very useful and agreeable form of fat, and is relished by almost every one. It is generally advisable to allow children to eat all the butter they want with bread, potatoes, or other food.

Eggs are less quickly digested when fried or hard boiled than they are when poached, soft boiled, or made into custard. Since many persons soon tire of them, it is better not to have them every day.

Roast beef, roast lamb, lamb or mutton chops, beefsteak, chicken, turkey, or fresh fish, at least once a day, are good for every one in ordinary health.

Potatoes contain a large amount of water and starch, but are deficient in proteid. Although there is not much nourishment in them, they are easily digested. Their value as food is increased when they are eaten with butter, cream, or meat gravy. Because of the greater heat to which potatoes are subjected when they are baked in their skins, they are more mealy

than when cooked in any other way, and so are more easily digested.

Other desirable vegetables are green peas, string beans, baked beans, spinach, stewed celery, and asparagus.

Rice, tapioca, and sago puddings are easily digested and wholesome.

Pork of any kind, salted meats, salted fish, veal, liver, kidney, goose, and duck are hard to digest. Green corn, radishes, raw celery, onions, tomatoes, carrots, and cucumbers are not easily digested, and contain only a small amount of nourishment. Hot bread, hot buns and rolls are hard to digest, and so are all cakes that contain dried fruits. Pies, tarts, pastry, nuts, candies, and salads are not easily digested, and should be eaten only in small quantities. Green or partly decayed fruit should never be eaten. Dried, canned, and preserved fruits and jellies are not so desirable as fresh, ripe fruit. It should not be understood that these articles of food are here condemned as unfit to eat. Many persons find them useful, nourishing foods; others find that they must refrain from the use of some of them. On the whole, these articles should not form so large a part of our diet as those mentioned in the desirable list.

How much to eat.—The amount of food, as well as the kind of food that one should eat, varies according to climate, occupation, and habits. Boys and girls need more food in proportion to their size than grown people do; for boys and girls must have material for growth as well as for repair of the tissues. People in cold climates need more heat-producing food than do people

in warm climates. Men that work hard in the open air need more food than men that work indoors.

Overeating.—The eating of an excessive amount of food at one or two meals may not cause very serious results, but continued overindulgence in eating is sure to lay the foundation of disease. There is a limit to the amount of food that can be digested in a given time. If too much food is eaten, it may not be properly digested in the stomach and the intestine. Fermentation and decomposition may then take place and give rise to acute indigestion or other trouble.

On the other hand, if an excessive amount of food is digested and taken into the blood, it will contain more food than the body needs. Part of this surplus food may be stored up in the tissues as fat. Part of it may be carried off through the liver and kidneys, and these organs will be overworked in their effort to get rid of the unnecessary food that was eaten. Many of the ills of the body arise from intemperate eating.

How much water to drink.—Water is taken either as plain water, or in the form of soups, or beverages, which consist largely of flavored water. It is probable that many persons do not drink enough water. The average healthy adult requires about a quart and a half or two quarts of water every twenty-four hours. The amount varies with the season; for more water is required in hot than in cool weather, because of the greater loss of water from the body by perspiration. It is a good plan to drink one or two tumblerfuls of moderately cold water on rising in the morning, and smaller amounts at inter-

vals during the day. One effect of cold water is to strengthen the muscles in the walls of the stomach and the intestine, and so enable them to do their work better.

Water enters the blood from the intestine. The presence in the blood of a sufficient amount of water makes it easier for the cells of the tissues to obtain food from the blood, and also to get rid of the waste matter that is continually being formed in them.

The drinking of very large amounts of water during, or immediately after, meals hinders digestion by diluting the gastric juice of the stomach and by overdistending that organ. The presence in the blood of too much water gives the heart too much work to do, and may be a cause of great danger if the heart or blood tubes are weak.

Cleanliness and food.—Great care should be taken to keep food clean. Food that is exposed for sale should be kept under glass, or should be otherwise protected from flies and from dust that is raised by wind or passing vehicles. The kitchen is, in many respects, the most important room in a house. Its walls, floors, and utensils should always be kept clean. Food should be kept covered in order to protect it from flies and other animals that convey germs of disease. Table refuse should be burned or should be promptly disposed of in some other way.

Flies.—The action of flies in spreading disease has only recently been fully recognized. Flies feed on all kinds of filth. Some of it adheres to their feet and other parts of their bodies. They may subsequently alight on meat, bread, or other food, or

fall into milk. In this way flies often deposit germs on food, and so spread contagious disease.

Flies should be kept out of the house. Windows and doors should be screened; and those that manage to get in should be killed by burning pyrethrum powder in the room, or in some other manner. Special care should be taken to keep flies from the kitchen, dining-room, and also from the sick-room if any one is ill with contagious disease. The number of flies would be greatly reduced if all kinds of filth both within and without the house were removed. Where everything is clean there are few flies.

Meal time.—Our meals should be at the same hours every day, and far enough apart to give regular intervals of rest for the stomach between meals. The stomach requires rest, if it is to keep in a healthy condition. In this country most people eat three times a day. Fruit, cereal, and eggs make an easily digested breakfast that is suited to most people. Bread and butter, meat, some vegetables, and a light pudding form a wholesome midday, or evening, dinner. Luncheon or supper, should be of simple and wholesome articles of diet. We must remember that the real purposes of eating are much more important than the pleasing of our palates. We eat to live, to grow, to keep warm, to have power, so that we may run, work, play, and think.

Rules for eating.—Here are a few simple rules in regard to eating, which should always be observed:

1. Eat slowly and chew the food well, so that it may become

well mixed with the saliva, and that there may be time for the saliva to act upon the starch which the food contains. When food is well separated and torn apart the gastric juice acts upon it more readily.

2. Stop eating as soon as you feel that your appetite is satisfied. The stomach acts best when it is about two-thirds full.

3. Take your meals at regular hours. The stomach requires a period of rest after the work of digesting a meal in order to make gastric juice for the next meal.

4. Do not eat between meals.

5. Supper, for children, should be the simplest and plainest meal of the day.

6. Do not drink while you have food in your mouth. Saliva mixes more readily with dry food.

7. Never drink ice water at meal times, or for two hours after a meal. Gastric juice is most active when the contents of the stomach are at or near the temperature of the body. A low temperature like that of ice water retards the action of gastric juice.

8. Do not drink cold water freely when the body is overheated.

9. Do not eat a hearty meal when very tired or very warm.

10. Rest, if possible, for at least half an hour after a hearty meal, in order that the stomach may have a better chance to do its work.

SUMMARY

1. Cooking makes meat and starch more digestible.
2. Cooking destroys parasites, and develops a flavor in food.

3. When meat is boiled or roasted it should be subjected to the greatest heat at first.

4. In making a stew or a soup with meat, the temperature should be kept low.

5. In frying, the fat should be very hot before anything is put into it to be cooked.

6. Potatoes are most easily digested when baked.

7. Articles of food that are digested with difficulty should be avoided.

8. Food should be kept clean, and should be covered to protect it from flies.

9. Flies convey germs and often spread contagious disease.

10. Meals should be at regular hours. The stomach needs an interval of rest between meals.

11. A few established rules for eating should be observed.

CHAPTER IV

DRINKS WHICH CONTAIN ALCOHOL

Many kinds of beverages containing alcohol are made in different parts of the world. These drinks differ from each other because they are made from different materials, and are prepared in different ways. Such beverages are known as wines of different kinds, beer and other malt liquors, whiskey and other distilled liquors.

Fermentation.—When the juice of apples, or other fruit, is exposed to the air at ordinary temperatures, bubbles of gas, called carbon dioxide, soon appear and rise to the surface, and at the same time alcohol is formed. The same thing takes place if yeast is added to a solution of sugar and water. The process by which sugar in a solution is changed into alcohol and carbon dioxide is called fermentation.

There are many varieties of fermentation. It is because of fermentation that wood, fruits, and other vegetables decay, that meats putrefy, and that sweet milk becomes sour. Milk becomes sour because tiny bodies, called *ferments*, enter it and change the sugar of the milk into lactic acid, which gives the milk a sour taste. If all the ferments could be kept out of milk it would not turn sour for months, or even years.

Fruit may be kept for a long time if it is first boiled and then put into air-tight vessels. The ferments that fall upon the fruit

from the air are killed by boiling, and fresh ones cannot enter vessels that are air-tight. Meat and vegetables are often preserved from decay in a similar manner.

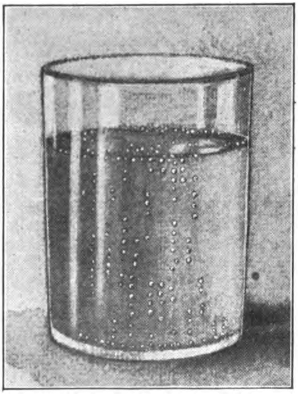
Fermentation of this kind is always caused by the action of tiny bodies which exist almost everywhere, and belong to the lowest order of plant life. These bodies are so small that we can see them only with the aid of a microscope, and for this reason they are sometimes called micro-organisms. They are called ferments because they cause fermentation.

YEAST CELLS
1. Before budding. 2. Budding to form more cells

Fermentation by which alcohol is formed in liquids containing sugar is caused by a ferment called the yeast plant. Each of these tiny plants consists of a single cell. In the picture the yeast plants are magnified. No. 1 shows single isolated cells or plants. No. 2 shows cells that are budding to form new plants. The spores of these plants correspond to the seeds of larger plants, and they float about in the air. Some spores drop into the fresh juice when wine or cider is being made and cause fermentation. The ferment, as it grows, takes nourishment from the sugar in the juice, and this so changes the sugar that alcohol and carbon dioxide are formed from it. The carbon dioxide comes up in bubbles to the surface of the juice and passes into the surrounding air, while the alcohol remains behind in the juice.

Wine.—The term wine is generally used to mean the fermented juice of grapes, but wine is made also from the juice of other fruits, such as currants, pears, cherries, and blackberries.

Grapes and other fruits contain no alcohol because the ferments remain on the skin, or outer part, and cannot enter the fruit to act on the sugar that forms in the fruit as it ripens. The fresh juice of all kinds of fruit consists chiefly of water and sugar, and is therefore harmless; but it remains so for only a short time. At the ordinary temperature that prevails at the time of the year when fruits ripen, ferments that get into the juice soon begin to grow and cause fermentation. The sugar in the juice is changed, and alcohol and carbon dioxide are produced. Ordinary wines contain from six to eleven per cent. of alcohol, but some contain even more.



FERMENTATION IN A GLASS OF CIDER

Cider.—Sweet cider ferments rapidly at a suitable temperature, and the sugar it contains is changed, forming alcohol and carbon dioxide. The amount of alcohol in cider depends upon the amount of fermentation that has taken place. The alcohol in cider varies from a fraction of one per cent. to about eight per cent. Cider is considered by many to be a harmless drink, but it is

not, for even what is sold as sweet cider often contains more alcohol than average beer.

Malt liquors.—Beer, ale, and porter are made from grain, generally from barley. The grain is first moistened and kept in a warm place until it sprouts, in order to change its starch into sugar. Then the grain, or malt as it is now called, is dried and ground, and the sugar is dissolved out with water. This is boiled with hops to give it a bitter flavor, and yeast is added to cause fermentation and produce alcohol from the sugar. The amount of alcohol in beer and other malt liquors varies from one to about nine per cent.

Distilled liquors.—When wine or malt liquor is heated sufficiently, the alcohol in it is changed into steam, or vapor, which rises and passes off from the liquor. Part of the water also in the liquor passes off as vapor along with the alcohol, but much of the water remains behind because alcohol boils at a temperature of 170° F., while water boils at a temperature of 212° F. If the vapor is collected and allowed to cool, it quickly changes back to a liquid which contains a greater proportion of alcohol than the wine or malt liquor. This process is called distillation. The more common distilled liquors are whiskey, brandy, rum, and gin.

Brandy is made by heating wine. As the vapor passes off it is collected and cooled. The new liquid, which is called brandy, contains more alcohol and less water than wine.

Whiskey and gin are made from starch obtained from grain or from potatoes. The starch is first changed to sugar, water is added to dissolve the sugar, and alcohol is formed by fer-

mentation, as in making beer. The liquid is then distilled. Whiskey, like brandy, is made up mainly of alcohol and water in about equal parts.

In making rum, water is added to molasses. This liquid is then fermented and distilled. The new liquid, which is called rum, contains a large amount of alcohol.

It is well known that Abraham Lincoln was a total abstainer from the use of alcoholic liquors, and that he urged others to abstain from drinking them. He is said to have composed and advocated the following pledge:

"Whereas, the use of alcoholic liquors as a beverage is productive of pauperism, degradation, and crime, and, believing it is our duty to discourage that which produces more evil than good, we therefore pledge ourselves to abstain from the use of alcoholic liquors as a beverage."

The following account is given of Lincoln's reception of the committee that came to notify him that he was nominated for the office of President in 1860:

"Mr. C. C. Coffin, a most distinguished journalist of the day, who accompanied the notification committee from the Chicago Convention to Springfield, at the time of Lincoln's first nomination for the Presidency of the United States, related in his newspaper a few days later an incident that occurred on that occasion. He says that, after the exchange of formalities, Lincoln said: 'Mrs. Lincoln will be pleased to see you, gentlemen. You must be thirsty after your long ride. You will find a pitcher of water in the library.'

"There was a humor in the invitation to take a glass of water, which was explained to Mr. Coffin by a citizen of Springfield, who said that, when it was known that the committee was coming, several citizens called upon Mr. Lincoln and informed him that some entertainment must be provided.

"'Yes, that is so. What ought to be done? Just let me know and I will attend to it,' he said.

"'Oh, we will supply the needful liquors,' said his friends.

"'Gentlemen,' said Mr. Lincoln, 'I thank you for your kind attention, but must respectfully decline your offer. I have no liquors in my house, and have never been in the habit of entertaining my friends in that way. I cannot permit my friends to do for me what I would not myself do. I shall provide cold water—nothing else.'"

SUMMARY

1. When a solution containing sugar ferments, alcohol and carbon dioxide are formed from the sugar.
2. The juice of apples, grapes, and other fruits contains sugar, and alcohol may be formed from any of them.
3. Alcohol may be made from grain. It is allowed to sprout so as to change part of its starch to sugar.
4. When steam from a heated liquid is collected and cooled down to a liquid again, the process is called distillation.
5. Distilled liquors contain more alcohol than wine or malt liquors.

PART II—THE FUNCTION OF NUTRITION

CHAPTER V

PLANT NUTRITION

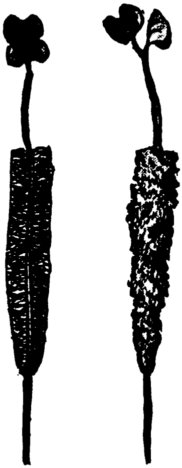
Food as a fuel.—When you see a steam-engine drawing a train, you know that it is using up fuel, and that more fuel will be needed from time to time to take the place of what is being consumed. And you know that if the supply of fuel should give out, the engine would soon stop and be unable to do any more work until it got a new supply.

In this respect, at least, living things, both plants and animals, are like an engine. When a plant or an animal works, you may be sure that it is using up fuel. Plants perform different kinds of work. They grow, move, and make leaves, flowers, fruit, and seeds. Animals, also, grow, move, build homes, seek food, and do many other kinds of work. The fuel which plants and animals use we call food.

An engine has a fire-box, and the fuel is all consumed in it. In plants and animals the food is not consumed in one place. Plants and animals, as you have already learned, are made up of little cells, and each cell consumes its own supply of food.

The coal consumed in an engine produces heat, and also the power that enables the engine to do work. An engine, however, cannot use the coal to repair itself as its parts wear out,

As food is consumed in the plant or the animal cell, heat and the power to grow and do other kinds of work are produced, and, in addition, the cell uses the food to make good the loss of its own cell-substance that is constantly wasting away. The process of using food for all these purposes is called nutrition.



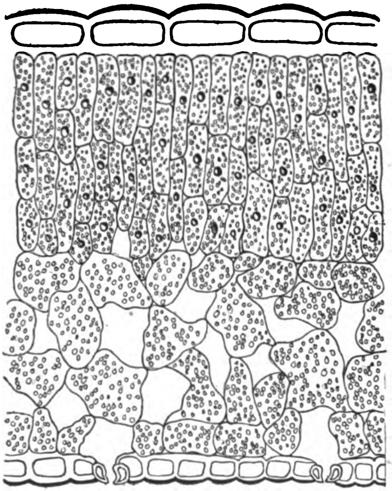
1 2

PLANTS WITH THEIR ROOT-HAIRS

1. Without dirt adhering to the hairs. 2. With dirt adhering to the hairs

Plants as manufacturers.—Most plants, *i. e.*, all green plants, have the power to manufacture their food from raw material. Animals cannot do this. It is commonly said that plants obtain their food from the soil through their roots and from the air through their leaves, but the fact is that a plant obtains from the soil and the air only materials out of which it makes its food. Near the tips of the roots of plants are root-hairs, each of which is a prolongation of the wall of a cell on the surface of the root. Through these root-hairs, or long cells, plants take from the soil water, which passes up through the body of the plant to its leaves. In this water are dissolved mineral substances that the plant uses in making food. On the under surfaces of leaves are many thousands of little openings called pores. Through these pores plants take from the air a gas called carbon dioxide, which they use in making food.

Water consists of a union of two gases, hydrogen and oxygen; carbon dioxide consists of a union of carbon and oxygen; starch consists of a union of carbon, hydrogen, and oxygen. Now, a chemist can separate water into hydrogen and oxygen, and carbon dioxide into carbon and oxygen. He knows how much carbon, hydrogen, and oxygen are needed to make starch; yet in his workshop he cannot put them together so as to make starch. But every green plant can do it. The green coloring matter in the leaf of the plant absorbs sunlight. The leaf-cells obtain from this sunlight the power to separate the hydrogen and oxygen of water, the carbon and oxygen of carbon dioxide, and to put together all of the carbon, all of the hydrogen, and some of the oxygen. Thus the leaf-cells make starch which the plant needs for food. The oxygen that the cells do not use goes out into the air.



SECTION OF LEAF SHOWING TWO PORES, P. P., ON UNDER SURFACE

Plants need, however, other kinds of food in addition to starch. These the green plants make by combining with the

materials contained in starch other materials, such as nitrogen, sulphur, and phosphorus. Plants obtain these, through their root-hairs, from water in the soil. Out of these materials they manufacture all the food that is needed to produce growth, repair waste, and do all of their other work.

Much of the food manufactured by the plant is insoluble (*i. e.*, cannot be dissolved) in sap, as the water in the plant is called; but the plant can change this food so that it is soluble in sap. When the food is dissolved it flows in the sap to the cells in all parts of the plant. As it is needed, the food then passes through the cell walls into the cells, and is there used up by the protoplasm. Now, this dissolving of food so that it can be carried by the sap and taken into the plant cells is similar to the digestion of food by animals. For, in the process of digestion in animals, the food is dissolved so that it can be distributed to the cells.

Green plants both manufacture and digest their food; other plants and animals can only digest food, they cannot manufacture it. All living things, therefore, both plants and animals, depend for their nourishment on this power of green plants to manufacture food from raw materials obtained from the soil and from the air; for some animals, the herbivorous ones, feed directly on plants, while others, the carnivorous ones, feed indirectly on plants by feeding on animals that feed on plants.

Oxidation in plants.—When you are starting a fire in a stove you keep the damper and the lower door open, so that

air may get to the fire; and, if the fire seems about to go out, you blow or fan it gently, so as to give it a greater supply of air. Air contains oxygen, which unites with the wood or coal in the act of burning. This uniting of oxygen with wood or coal is often called combustion, or oxidation. In the case of wood or coal, oxidation is so rapid that light is produced, as well as heat and power. Like the fire, plants must have air so that oxygen from the air may unite with food in the cells and furnish heat and the power to work. Oxidation in the cells of plants takes place more slowly than the combustion in a stove, and therefore light is not produced.

In the body of a plant there are spaces between the cells. These spaces form continuous passages throughout the plant body and connect with the air by means of openings, or pores, at the surface. The pores are very numerous on the under side of the leaf, and there are also pores through the bark. When oxygen from the air has entered through the pores into the air-spaces, it passes on through the cell walls into the cells, and is there used by the protoplasm in oxidizing the food.

When food is oxidized in the cell, waste matter is produced which the cell must get rid of. This waste matter consists largely of carbon dioxide, and water in the form of vapor. These pass through the cell wall into the spaces between the cells and out of the plant through the pores on the surface.

This escape of carbon dioxide through the pores of the leaf can best be observed at night, when the leaf is not absorbing carbon dioxide from the air. During the daytime, carbon di-

oxide that is given off from the cells as waste matter mingles in the leaf with that absorbed from the air, and is used in making starch.

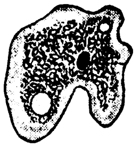
SUMMARY

1. When an engine, a plant, or an animal does work it uses up fuel.
2. Green plants manufacture food from raw materials obtained from the air and the soil.
3. They take in raw material through root-hairs and pores in their leaves.
4. Green plants make starch in their leaves from carbon dioxide and water.
5. To the materials used in making starch, green plants add other materials to make proteids and oils.
6. Green plants digest food after they manufacture it.
7. Animals and other plants digest food, but cannot manufacture it. They depend upon green plants for food.
8. Plants take in oxygen and oxidize food in their cells.

CHAPTER VI

ANIMAL NUTRITION

The simplest kind of animal nutrition.—In an earlier chapter you learned something about the tiny animal called the amœba, which consists of a single cell. It consists of protoplasm without any covering, or skin, so it does not need any mouth. It can send out at any point a little projection that creeps around a food particle—consisting usually of a tiny plant—and encloses it, together with a little water. When the food particle and the water are enclosed within the body of the amœba, a fluid, which the little animal makes, dissolves, that is digests, at least part of the food. The part that is dissolved is taken up by the protoplasm and used in repairing waste and in producing heat and the power to work. The part of the food material that cannot be dissolved may be given off at any point from the surface of the amœba. The type of nutrition in the amœba is the simplest kind of animal nutrition.

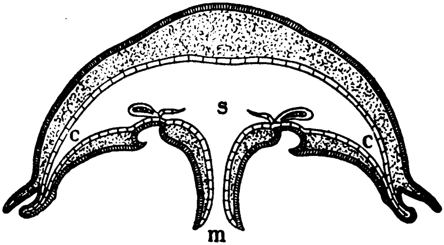


AN AMŒBA

The jelly-fish.—A jelly-fish is higher in the scale of animal life than an amœba and shows a more advanced type of nutrition. In the jelly-fish shown in the picture there is a mouth

A JELLY-FISH

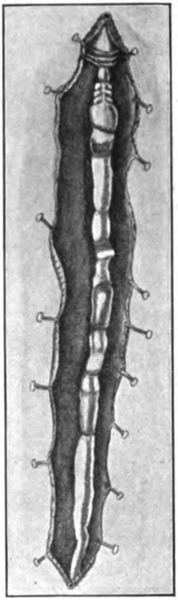
on the under surface of the umbrella, and above the mouth there is a sac-like stomach. A long arm extends downward from each of the four corners of the mouth. As tiny animals in the water drift against these arms they are paralyzed or killed by stinging cells, and are afterward drawn into the mouth and the stomach. The part of the food that cannot be digested is cast out later through the mouth; but the part that has been digested is conveyed to all parts of the body by little tubes that run out from the stomach in all directions. In these animals the food that is used up in the cells comes to them directly from the stomach.



SECTION OF JELLY-FISH
(*m*) Mouth. (*s*) Stomach. (*c*) Tube

The earthworm.—The common earthworm is higher in the scale of animal life than the jelly-fish, and,

accordingly, shows a still more advanced type of nutrition. A straight tube, called the alimentary canal, extends from one end of its body to the other. Food material, or soil containing food material, is taken in at the mouth, which is the beginning of the alimentary canal. This food material on its way along the canal passes into the part called the esophagus, and then enters another part called the gizzard. The gizzard has a thick muscular wall lined with a horny membrane. In this part of the canal the food material is rolled about and ground fine to get it ready for digestion. On leaving the gizzard the food material passes into a part of the canal that has a thin wall. Cells in the wall of this part secrete a fluid that digests the food material that can be digested. The indigestible part passes on and leaves the alimentary canal through an opening at its end.



ALIMENTARY CANAL OF EARTHWORM

(For blood tubes, see chap. xvi. p. 224)

The simplest type of blood circulation.— The cells of the body of the earthworm do not receive digested food directly from the alimentary canal, as in the jelly-fish. The food that has been digested passes through a thin membrane into little blood tubes in the wall of the canal, and then along blood tubes to all parts of the body. The earthworm has no heart, but blood is

forced to all parts of the body by muscles in the walls of the larger blood tubes, and the cells get their food from the blood.

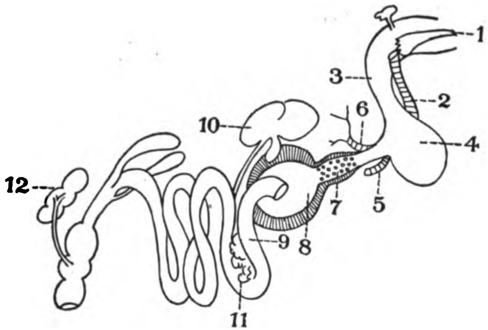
Higher types of nutrition and circulation.—The plan, as seen in the earthworm, of an alimentary canal for digesting food, and of a system of blood tubes for distributing digested food to the cells, is found in all higher animals. But the supply of food needed by larger and more active animals is so much greater than the supply needed by the small, sluggish earthworm that an alimentary canal consisting of a straight tube would not digest enough food for them. While, therefore, the general plan of nutrition in the higher animals is the same as in the earthworm, yet the alimentary canal and the organs for distributing food by means of blood tubes are changed so that they can furnish to these larger, more active animals the greater supply of food required.

A marked addition to the food-distributing organs of higher animals is an organ called the heart, which is composed of muscle, and has for its special work the forcing of blood along the blood tubes.

Modifications of the alimentary canal.—One way in which the alimentary canal of higher animals is modified is by being distended into a sac—the stomach—into which food is received from the mouth, and detained until partly digested.

Another modification is the arrangement of the intestine in loops. This arrangement allows a greater length of intestine to be tucked away in a small space; and the greater length of intestine gives increased power to digest food.

Another modification is the large groups of cells, called glands, which make from the blood the fluids that are poured into the canal and aid digestion. One of these fluids is the saliva of the mouth. These are in addition to the digestive fluids that are secreted in the walls of the stomach and intestine.



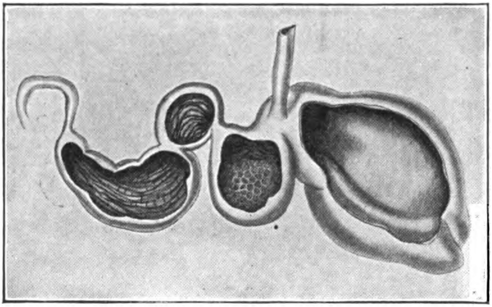
ALIMENTARY CANAL OF BIRD

1. Tongue. 2. Windpipe. 3. Esophagus. 4. Crop. 5, 6. Bronchi. 7. Stomach containing gastric glands. 8. Gizzard. 9. Intestine. 10. Liver. 11. Pancreas. 12. Kidney

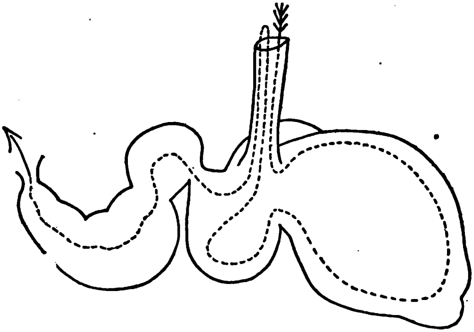
Birds.—As birds have no teeth they cannot break up grain in their mouths. The grain passes on at once to an enlargement of the canal, called the crop, where it is moistened with saliva. Farther along the canal there is an oval enlargement of the canal called the gizzard. Its two sides consist of thick muscular walls, lined with a tough, horny membrane. Between the walls of the gizzard the moistened grain is crushed and ground into fine particles. The gizzards of these birds always contain small pebbles, or other hard substances, which were swallowed to aid in the crushing of the grain. On leaving the gizzard the crushed grain passes on into the intestine, where digestion is completed.

Cud-chewing animals.—Still another arrangement of the

alimentary canal is seen in the stomach of cud-chewing animals, such as the cow, sheep, goat, deer, camel, and antelope, which feed upon grass and other vegetable food. The stomach of these animals is divided into different compartments, usually four in number. A cow tears off the grass, chews it slightly, mixing it with saliva, and then rolls the moistened grass into a ball and swallows it. This ball of grass passes down the esophagus into the first, and largest, chamber of the stomach, and from there passes on into the second chamber. When the cow is ready to chew her cud, a ball of the food is forced up the esophagus into the mouth. It is then chewed and mixed with saliva until it becomes semi-fluid, when it is swallowed a second time. This time the openings into the

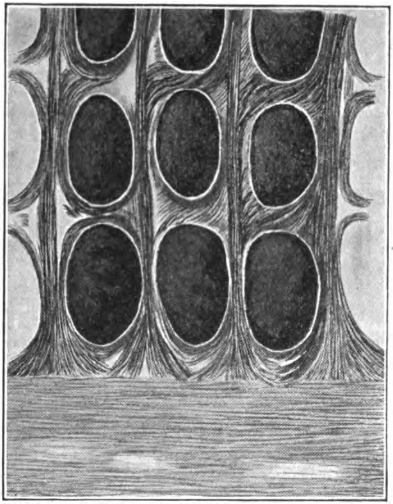


A COW'S STOMACH



SECTION OF A COW'S STOMACH

first and second chambers are closed and the food passes into the third chamber, and thence into the fourth, where it is mixed with another digestive fluid. In time the food passes on into the intestine, where digestion is completed.


WATER POCKETS IN CAMEL'S STOMACH

Another interesting modification of the alimentary canal is found in the camel. This animal is often unable to find water for days at a time. On the inner surface of the first and second chambers of its stomach is a large number of little pockets, or water cells, which can be closed up. In these water can be stored so as to be used later when needed. Because of this storage of water, a camel can travel across a desert for four or five days, or even longer, without drinking. Some persons believe that during journeys in the desert camels are sometimes killed in order that their drivers may relieve their own thirst with water from the stomach of the camel. But camel drivers say this is not true.

Oxidation in animals.—Since food has to be oxidized in the cells of the body, in order to produce heat and the power to

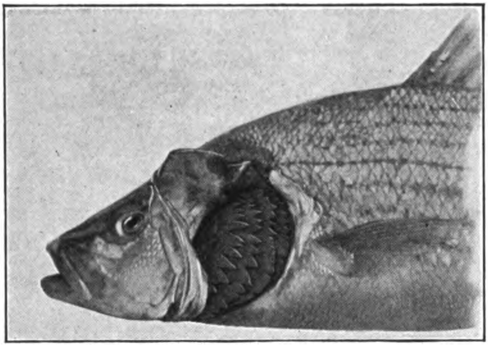
work, it is necessary that the cells should receive also a supply of oxygen. This oxygen is obtained directly from the air by animals that live on land, and from air contained in water by animals that live in water. Perhaps you do not know that water contains air, but you can easily prove it for yourself. If you will let a glass of water stand for some time in a warm place, small bubbles of air from the water will accumulate on the inner side of the glass. When water in a vessel is heated over a fire, bubbles of air are driven off before the water commences to boil, and if a fish is placed in water that has been boiled and cooled, it will die from lack of air, for the air was driven out of the water by the heat.

In the case of lower animals that live in water, oxygen passes through the surface of the body and also through the lining of the digestive sac into spaces between the cells. The oxygen then passes along these spaces, and the cells take what is needed for the purpose of oxidation.

The earthworm breathes through its skin. In its skin there is a vast number of minute blood tubes. Oxygen from the air passes through very small pores in the skin and through the thin walls of the minute blood tubes into the blood, which conveys the oxygen to the cells of the body. If the earthworm is exposed to the heat of the sun, its moist skin soon becomes dry, and the worm dies because it can no longer breathe through its skin. Oxygen will pass through an animal membrane only when it is moist.

In larger, more active animals, however, there is need of a

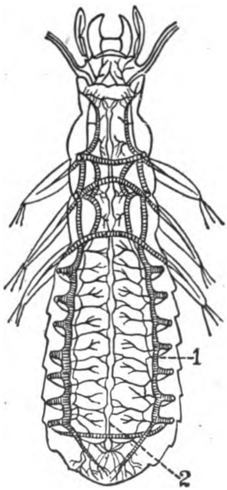
greater supply of oxygen, and in such animals there are special organs by means of which oxygen is obtained either from the air, or from air contained in water. An example of such special organs may be seen in the gills of common fishes. The gills lie just behind the mouth. The fish takes water into its mouth, and then, by an act that resembles swallowing, causes this water to pass out over the gills. Only a thin membrane separates the blood in the blood tubes of the gills from the surrounding water. In this membrane are pores so fine that oxygen can pass through them into the blood, but the water cannot pass through to the blood, and the blood cannot pass through to the water. This oxygen is then conveyed in the blood to the cells of the fish's body and used to oxidize food. A fish cannot use oxygen from the air. When the little leaflets of their gills become dry, breathing becomes impossible; for a supply of oxygen from the air can pass through animal membranes only when these membranes are moist.



GILLS OF A FISH

Insects are very active, and require a large amount of oxygen in order to oxidize sufficient food to enable them to make their

rapid and frequent movements. Insects, accordingly, have another kind of breathing apparatus. Along their sides are small openings; air-tubes extend inward from these and branch off to all parts of the body. By means of these fine air-tubes, air is conveyed directly to the spaces between the cells in all the tissues, and the cells take from the air the oxygen that they need.



AIR-TUBES OF A BEETLE

1. Air-tubes (shaded). 2. Nerves

In higher animals there are organs called lungs in which oxygen from the air enters the blood. Animals that breathe by lungs cannot take the oxygen that they need from air contained in water, and soon die if kept under water. Many lung-breathing animals, such as beavers, otters, seals, and walruses, spend much of their time in water, while whales spend all of their time in water. These animals can remain under water only a short time; they must come to the surface to breathe. A whale usually comes to the surface to take breath every ten or fifteen minutes. Seals are said to come to the surface about every seven minutes, and in winter, when wide areas of the sea are covered with ice, they keep holes open to which they come to take breath.

Some animals, like the frog, can breathe both in air and in water. When on land a frog breathes through its lungs, but

when under water it breathes through its skin. Its skin is abundantly supplied with small blood tubes, and oxygen from the air contained in water passes through the thin wall of these blood tubes into the blood.

Waste matters.—Whenever food is oxidized in an animal or a vegetable cell, waste matter is produced that consists chiefly of carbon dioxide, and water in the form of vapor. The cell must get rid of these, and they pass out of the body in the same way that the oxygen enters, but in the opposite direction.

In both the plant and the animal cell, the wearing out of protoplasm produces waste matter. In the plant cell, the protoplasm can use this waste matter again in the act of repairing its loss; but in the animal cell, this waste matter must be got rid of. It passes out of the cell and is finally cast out of the body. In the highest class of animals, the mammals, this waste matter is called urea. It passes out of the cell into the blood, and is later taken from the blood by the kidneys. If this waste matter should remain in the body it would act as a poison and cause death.

SUMMARY

1. Even one-celled animals, such as the amœba, take food into their bodies, digest it, and use it up.
2. Such animals as the jelly-fish digest food in a stomach, and the digested food goes directly from the stomach to the cells of the body.
3. The earthworm has an alimentary canal for digesting food, and a set of blood tubes for conveying it to the cells of the body.
4. In higher animals, a heart forces blood along the blood tubes.
5. In higher animals, there are modifications of the alimentary canal.

6. Birds that eat grain have a gizzard to grind it.

7. The stomach of cud-chewing animals is divided into compartments.

8. A camel has in the wall of its stomach pockets in which to store a supply of water.

9. Water contains air dissolved in it.

10. Lower animals living in water get oxygen through the surface of the body and through the lining of the stomach.

11. The earthworm gets oxygen from the air through the skin if it is moist, but cannot if it is dry.

12. Fish get oxygen through the gills from air in water.

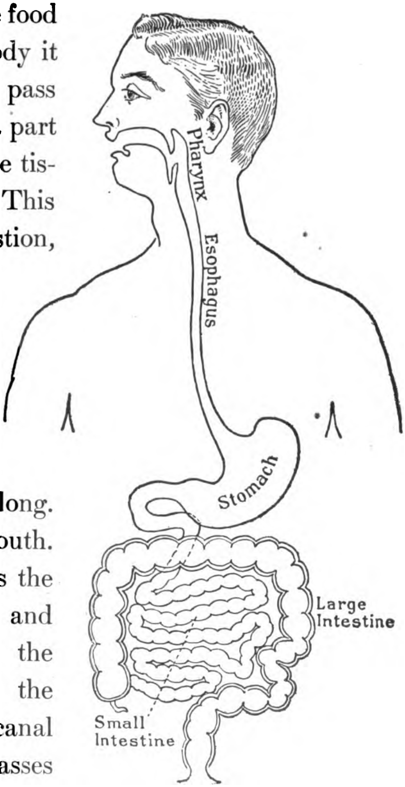
13. Insects have air-tubes through which air goes directly to the cells of their bodies.

14. Higher animals breathe by lungs. They take oxygen from air, but cannot take it from air dissolved in water.

CHAPTER VII

DIGESTION

What digestion is.—Before food can be used to nourish the body it must be changed so that it can pass into the blood tubes, become a part of the blood stream, flow to the tissues, and feed their cells. This changing of food is called digestion, and is carried on in the alimentary canal.



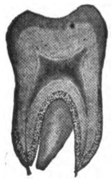
ALIMENTARY CANAL

The alimentary canal.—This canal is one long food tube and different parts of it have different names. The whole tube is about thirty feet long. Its upper opening is the mouth. Next comes the part known as the pharynx, which is about four and one-half inches long. Below the pharynx the canal is named the esophagus. This part of the canal is about nine inches long, and passes through the diaphragm into the abdo-

men. Here the tube expands into a sac called the stomach. Then it narrows again into the coiled part known as the small intestine, which is about twenty-five feet long. The tube then widens and ends in the large intestine, which is about five feet long. The work of digesting food begins in the mouth, and is continued in the stomach and in the intestine.

DIGESTION IN THE MOUTH

Mastication.—In the mouth, food is torn apart, moistened, and softened. The grinding and tearing are done by means of the teeth, assisted by the cheeks, the lower jaw, and the tongue. By means of powerful muscles the lower jaw can be moved freely back and forth, sidewise, and up and down. Into it is set a semi-circle of teeth that work with tearing and grinding movements against another semi-circle of teeth in the upper jaw. The upper jaw is immovable.



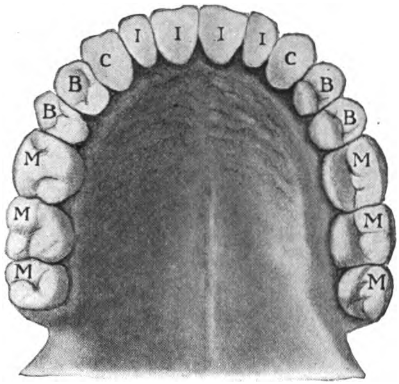
A SECTION OF A TOOTH, SHOWING ENAMEL, CROWN, CAVITY, AND ROOTS

Each tooth consists of a crown, a neck, and a root or roots.

The crown is the part above the gums, and is visible in the mouth. The neck is the narrowed part between the crown and the roots. The roots fit into holes in the jaw-bone.

A tooth is hollow. Here is a picture of half a tooth that has been cut open. The central hollow portion contains the pulp. This pulp is composed largely of blood tubes and nerves which enter the teeth through openings in their roots.

Three kinds of material make up the solid portion of a tooth. The main part is composed of a bony substance called dentine, which surrounds the pulp cavity. The crown is coated with a hard, white, shining material called enamel — the hardest substance in the body. The root is crusted over with a cement that resembles bone in structure.



A SET OF UPPER TEETH

The first tooth usually appears at the age of six or eight months, and is followed by others at irregular intervals, until the first, or temporary, set of twenty teeth is complete, at about the age of two and a half years.

The second, or permanent, teeth begin to appear, as a rule, during the sixth year, and the whole set is generally complete by the twenty-fifth year. The permanent set consists of thirty-two teeth. The upper and lower jaws each contain four incisors, two canines, four bicuspids, and six molars. The incisors and canines have thin, cutting edges and are useful for biting. The bicuspids and molars have broad surfaces, which are used in grinding the food.

Care of the teeth.—If a muscle, a bone, or a portion of the skin is injured, it at once begins to try to heal itself—and usually succeeds. But, unlike other parts of the body, the teeth

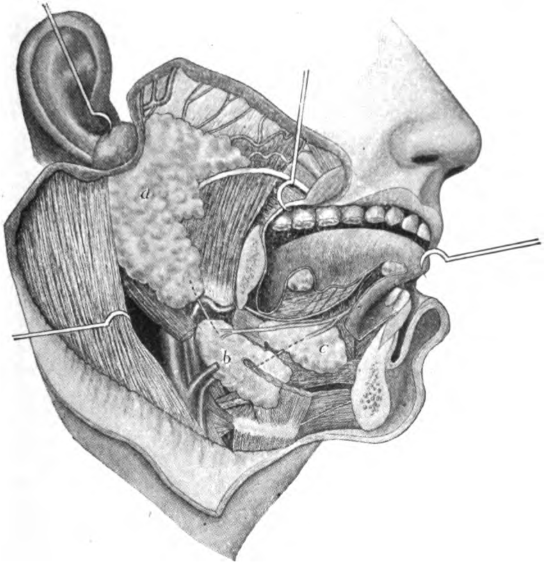
have no power to repair any injury that may happen to them. It is important, therefore, to save them from injury as much as possible. To this end they should be kept scrupulously clean. Particles of food that are allowed to remain between the teeth decompose quickly, owing to the heat and moisture of the mouth. Decomposing food makes the breath unpleasant, and forms acids that injure the enamel and cause the teeth to decay. A soft wooden toothpick, or a piece of silk thread may be used to remove particles of food from between the teeth, but pins or metal picks should not be used, because the enamel is likely to be injured by them. It is not safe to crack nuts with the teeth, or to bite hard objects of any kind, because in this way a piece of the enamel may be broken off. Whenever the enamel is broken off, the tooth may decay and a cavity be formed. If the decay proceeds until a nerve is exposed, the tooth may become very painful. Every one should have his teeth examined twice a year by a dentist, so that cavities may be promptly found and filled, and the gums may be treated, if they are receding.

How saliva is made.—Saliva, the digestive fluid that moistens the mouth, is made in small organs called salivary glands. A gland consists of a group of cells surrounded by a network of fine blood tubes. The cells of a gland take up certain materials from the blood, and from these make a new material, which is called a secretion. Little tubes, called ducts, convey the saliva from the glands to the mouth.

There are three pairs of salivary glands. One pair, the

parotids, lie just under each ear. Another pair, the submaxillary glands, lie in the front of the neck below the angle of the lower jaw. A third pair, the sublingual glands, lie under the tongue.

When a person is not eating, these glands work slowly, and

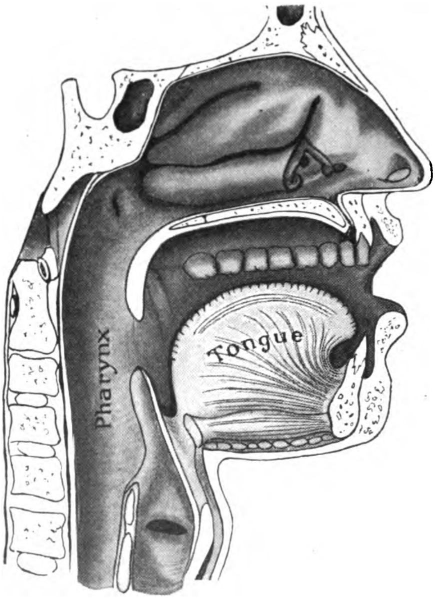


THE SALIVARY GLANDS, *a*, *b*, AND *c*

just enough saliva is made to keep the mouth moist. But when food is taken into the mouth, they work rapidly, and saliva is poured out in abundance. The amount of saliva made in twenty-four hours is estimated to be about a pint and a half.

How saliva acts on food.—The chief purpose of saliva is to moisten and soften dry food. Moist food is easily masticated and swallowed.

In addition to this, saliva contains a kind of ferment, called *ptyalin*, that acts on starch and changes it into a kind of sugar called maltose. Starch will not dissolve in a fluid, nor will it pass through the walls of the blood tubes. Sugar, however, will dissolve and will pass through the walls of the tubes into the blood. But saliva does not act on meat or other proteid food, or on fats. During an ordinary meal some of the starch in food escapes the action of the saliva and reaches the stomach as starch; some is partly changed, and some is completely digested and reaches the stomach as sugar.

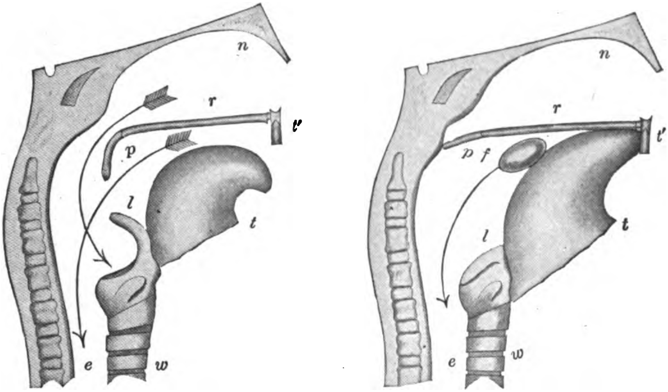


THE PHARYNX

If we eat rapidly there is not time for the mixing of a sufficient amount of saliva with the food. We should, therefore, always eat slowly, and chew the food until it is in fine particles.

How food is swallowed.—When food is sufficiently moistened and masticated, it is pressed backward by the tongue, and passes into the part of the alimentary canal called the *pharynx*.

The pharynx lies behind the mouth, and leads to the esophagus. After the food has been pressed backward by the



THE PARTS OF THE MOUTH IN BREATHING

THE SAME PARTS IN SWALLOWING

n, the nasal cavity; *r*, roof of the mouth; *p*, soft palate; *l*, lid over opening into windpipe; *w*, windpipe; *e*, esophagus; *t*, tongue; *t'*, tooth; *f*, food that is being swallowed (Landois and Stirling)

tongue, the muscles in the wall of the pharynx contract and force the food on into the upper end of the esophagus. In the wall of the esophagus are muscles arranged, for the most part, in a circular manner. In the act of swallowing, muscles behind the food contract, narrow the esophagus, and thus keep pushing the food onward until it reaches the stomach. Drink is swallowed in exactly the same way as food. It does not run down the esophagus itself, but each portion that is swallowed is forced

along by contraction of muscles behind it. This explains how horses and many other animals are able to drink when their heads are low, and how a juggler can drink while standing on his head.

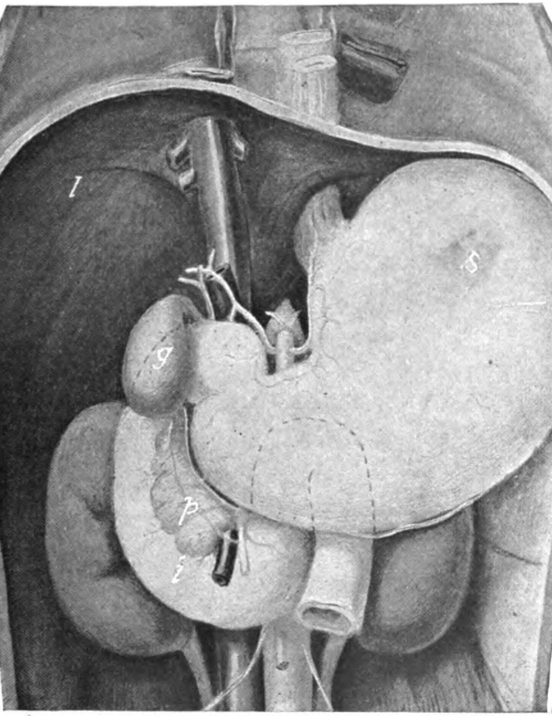
The pharynx connects also with the nose, and air on the way from the nose to the windpipe passes through the pharynx. As food is going back into the pharynx it must pass over the entrance to the windpipe. This entrance is called the *glottis*, and is guarded by a lid called the *epiglottis*. When we are breathing, the epiglottis remains up, so that air may pass freely from the nose to the windpipe; but, when we swallow anything, the epiglottis bends over and covers the glottis. If a drop of water, or a tiny morsel of food, enters the windpipe, a fit of coughing is sure to follow in order to expel it.

DIGESTION IN THE STOMACH

Location of the stomach.—As you will see from the picture on page 75, the stomach lies in the upper part of the abdomen, on the left side, just under the heart. It has two openings. The upper one, by which food enters from the esophagus, is called the cardiac opening. The lower one, through which the partly digested food passes into the intestine, is called the *pylorus*, or gatekeeper.

What the stomach is.—The stomach is a sac-like part of the alimentary canal. In its wall are layers of muscle. The inner surface of the stomach has a soft lining of *mucous* membrane, a kind of skin that lines the interior surface of the whole

of the alimentary canal and all other cavities that communicate directly with the air. At the lips, where it joins the outer skin,

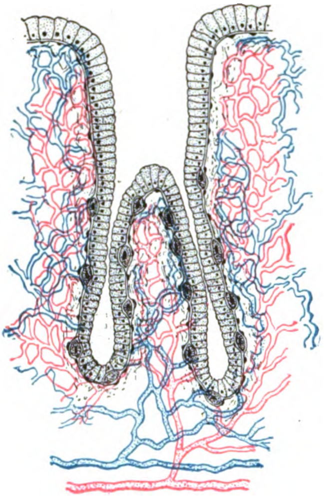


STOMACH IN ITS NATURAL POSITION

s, stomach; *l*, liver; *g*, gall bladder; *p*, pancreas; *i*, intestine

this membrane may be seen. Mucous membrane contains small glands that secrete a watery fluid, called *mucus*, which is poured out on the surface of the membrane to keep it moist.

The size of the stomach varies from time to time. When it contains no food its wall contracts and it becomes smaller. The entrance of food causes it to dilate again.



GASTRIC GLAND
(Magnified)

The muscles in the wall of the stomach are gathered into a thick, circular ring at the pylorus. When this ring of muscle contracts, the gateway is closed, so that no food can go through. When these muscles relax, the gateway opens and the contents of the stomach are allowed to pass into the intestine.

Gastric glands.—The mucous membrane lining the stomach is composed almost wholly of small tubular glands, which secrete a juice called *gastric juice*.

This is a sketch of a gland that secretes gastric juice. A gastric gland is surrounded by a network of tiny blood tubes, called capillaries. The cells in the lower part of the gland absorb material from the blood in the tubes, and from it make the juice which flows through the upper part of the gland into the stomach. When no food is in the stomach the cells rest, and when food comes in they work rapidly, and an abundant supply of gastric juice is made and poured on the food.

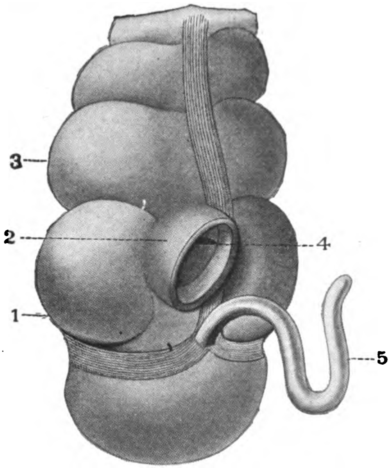
Gastric juice looks like water. It contains a small amount of acid, which gives it a sour taste. It also contains substances called ferments. One of these, *pepsin*, can digest all forms of proteid food, while another, *rennet*, or *rennin* as it is sometimes called, assists in the digestion of milk.

As soon as food of any kind enters the stomach, tiny drops of gastric juice appear at the mouths of the glands, trickle down the sides of the stomach in small streams, and mingle with the food. At the same time, movements of the stomach begin. Muscles in the wall of one end of it contract and cause the food to flow in the gastric juice toward the other end. Then the muscles in the wall at the other end contract and cause the food and the gastric juice to flow back again. These movements are called the *peristaltic* movements of the stomach. By them the gastric juice and the food are thoroughly mixed together. The digestion of food in the stomach is slow when it is too full. The peristaltic movements take place more readily when the stomach is about two-thirds full.

How gastric juice acts on food.—Gastric juice digests all forms of proteid food, such as those found in lean meat, eggs, milk, and vegetable food. By its action, these foods gradually fall apart and become dissolved in the juice itself. Gastric juice does not dissolve fat or starch. When milk is taken into the stomach it is first curdled by the rennet of the gastric juice. Then the pepsin dissolves the curdled lumps and digests the proteid they contain.

Babies often throw up part of a meal of milk in a curdled

condition. The throwing up is nature's way of getting rid of part when too much is taken, and does not always mean that the baby is ill, or that he is unable to digest his food. The curdling shows that digestion has already begun, for curdling is the first step in the digestion of milk. The curds are always larger and firmer when cow's milk is used. In feeding infants on cow's milk the curds will be softer and more finely divided if a tablespoonful of lime-water, or barley-water, is added to each feeding.



END OF LARGE INTESTINE

1. Cæcum. 2. Ileum. 3. Colon. 4. Valve of Ileum. 5. Appendix

As soon as a portion of the food in the stomach becomes dissolved the muscles at the cardiac end contract and the food is pushed toward the pylorus. The thick ring of muscle that closes the pylorus relaxes and allows the more liquid contents to escape into the intestine; but on the approach of lumps of undigested food the pyloric ring closes quickly. The peristaltic movements of the stomach then continue until another part of the food is dissolved, when it, in turn, is forced on into the intestine.

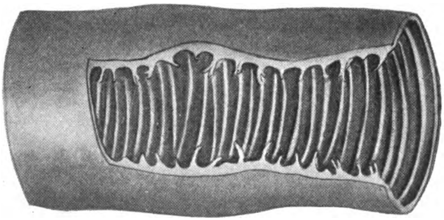
The length of time during which food remains in the stomach

varies much under different circumstances. On an average, the stomach is nearly, if not quite, empty in four or five hours after a meal.

Until recently it was supposed that a man could not live without his stomach, but cases have been recorded in which the stomach was removed because of disease, and the patient continued to live.

DIGESTION IN THE INTESTINE

What the intestine is.—The intestine is the part of the alimentary canal that extends downward from the stomach, forming the lowest part of the canal. The upper part of the intestine is small in diameter, and is called the small intestine. Its average length is about twenty-five feet. The lower part is larger in diameter, and is called the large intestine. Its length varies from four and a half to five feet.



SECTION OF SMALL INTESTINE

Different parts of the intestine have different names. The first ten or twelve inches from the stomach are called the *duodenum*. The first two-fifths of the rest of the small intestine are called the *jejunum*, and the remaining three-fifths are called the *ileum*, which opens into the large intestine. The name *colon* is given to the part of the large intestine that is above the valve of the ileum, and the

name *cæcum* is given to the short part below the valve. From the cæcum there is a worm-like projection called the *vermiform appendix.* In the disease appendicitis there is an inflammation of the appendix.

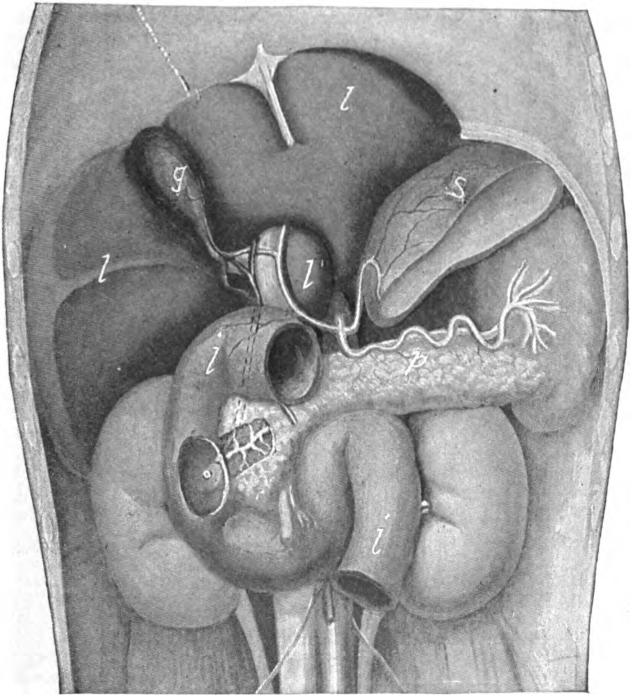
The wall of the intestine consists largely of muscle. On the inside it has a soft lining of mucous membrane. A picture of the mucous membrane of a part of the small intestine is shown on page 79. The membrane is drawn up into folds, and this arrangement increases its secreting surface. The folds also retard the passage of food along the intestine, and allow more time for digestion.

The process of digestion is completed in the intestine. When the food leaves the stomach it is a thick, soup-like fluid, called *chyme.* It contains undigested starch that has escaped the action of saliva, undigested proteid that has escaped the action of the gastric juice, portions of starch and proteid only partly digested, and also digested proteid, sugar, fat, water, and salts.

Food is digested in the intestine by the action of the *pancreatic juice,* which is made in the pancreas; the *bile,* which is made in the liver; and the *intestinal juice,* which is made by glands in the wall of the intestine.

The pancreas.—The pancreas lies in the abdomen, behind the lower part of the stomach and the upper part of the intestine. It is a long gland, of a reddish cream color, resembling the salivary glands, and has often been called the abdominal salivary gland. The pancreas of the ox and other animals is known by the name of sweetbread, which we often use as food.

How pancreatic juice acts on food.—The pancreatic juice is the most important of all the digestive juices, for it contains



THE LIVER AND PANCREAS
Part of the stomach cut away to show pancreas
l, liver; *g*, gall bladder; *s*, stomach; *i*, intestine; *p*, pancreas

three ferments. One of these acts on starch, changing it to maltose, a kind of sugar. This action resembles the action on starch of ptyalin in the saliva, but is more rapid. Another fer-

ment digests proteids. Its action resembles that of the pepsin in gastric juice. The third ferment acts upon the fats in the food, and digests them. The pancreatic juice enters the duodenum through a duct, or tube, about four inches below the pylorus.

The liver.—You have often seen ox liver or calf liver. The human liver, as you will see from the picture on page 81, resembles ox liver. It lies under the diaphragm, close to the lower ribs of the right side. As it is the largest gland in the body, and one of the most important, it has a number of duties to perform. Among these is the making of bile. The liver is made up of cells and blood tubes, held together by connective tissue. These cells take from the blood what is necessary to make bile. When digestion is going on, the bile comes directly from the liver to the intestine, through a little tube. The tube from the pancreas and the one from the liver unite and the bile and pancreatic juice enter the duodenum by the same tube. When digestion is not going on, the bile is stored up in a little pear-shaped bag, the gall bladder, which is tucked away under the liver. It is very necessary to health that the bile should escape from the liver to the intestine. When for any reason the bile cannot escape readily enough, it passes into the blood, and is carried to all parts of the body, causing a condition known as jaundice.

How bile acts on food.—The bile by itself has little or no power to digest food. It aids the pancreatic juice, especially in digesting fats, lessens fermentation in the intestine, and

stimulates the peristaltic movements of the wall of the intestine, which cause its contents to move along toward its lower end.

How the intestinal juice acts on food.—The action of the intestinal juice on food is caused by a ferment that has the power to change cane-sugar and maltose into grape-sugar. It has also some power to change starch into grape-sugar.

The muscles in the wall of the intestine, by their contractions, which are called peristaltic movements, force the food along and cause it to become thoroughly mixed with the pancreatic juice, the bile, and the intestinal juice.

As a result of the changes produced by the action of the digestive fluids of the mouth, the stomach, and the intestine, the food which was swallowed as meat, bread, butter, and so on, becomes liquefied. The part of this liquid that is fit to nourish the body is now ready to be taken out of the intestine into the blood tubes, where it will become a part of the blood.

A part of our food, however, is not fit to nourish the body. This part, consisting of indigestible and undigested matter, cannot be taken into the blood. It remains in the intestine and is forced along by the contraction of muscles in the intestinal wall, until it passes out of the body as useless material. It is important that the bowel, as the intestine is sometimes called, should get rid of this useless material every day. Regular habit in this matter is necessary in order to avoid constipation and other troublesome disorders.

ABSORPTION OF FOOD

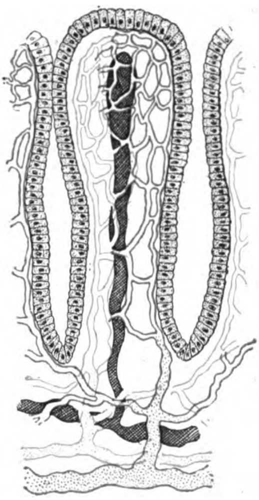
You have now followed the process of digestion until it is completed in the intestine. There in the intestine is the material that will supply heat, repair waste, and produce the power to work. How are the muscles, the bones, the brain, and all the different parts of the body to get this material? They cannot go to it. It must be brought to them. The first step is to get this food into the blood.

A small amount of sugar and even some digested proteid food pass through the mucous membrane of the stomach into the blood tubes in the wall of the stomach, become part of the blood stream, and flow in the blood to the different parts of the body. But the main portion of food gets into the blood from the intestine.

The villi.—When the surface of the mucous membrane that lines the small intestine is examined carefully, it is seen to have a velvety appearance. This is owing to the presence of a very large number of tongue-like bodies, called villi. There are about four millions of these villi in the small intestine, but none at all in the large intestine. The use of the villi is to absorb food from the intestine so that it may pass on into the blood.

In the picture of a villus, which is highly magnified, you can see that it is composed of three main parts—a layer of cells on the surface; a network of very small blood tubes, called capillaries, underneath; and a larger tube, called a lacteal, in the centre. The arteries that lie in the mucous membrane of the

intestine send a branch up to the base of each villus, and this branch, passing upward into the villus, divides into many small branches, forming a capillary network just under the layer of cells. At the opposite side of the villus these capillaries unite to form a vein that passes down to join a larger vein in the mucous membrane of the intestine, below the base of the villus. The lacteal of the villus joins a tube below, called a lymph tube. Lymph tubes contain a colorless, watery fluid called lymph. It is derived from the blood, and, later, it passes back into the blood.



VILLUS
(Magnified)

The villi project inward from the entire inner surface of the small intestine, and their cells are bathed by any liquid contained in the intestine. As the digested food, which is now in liquid form, moves along in the intestine, the cells of the surface of the villi absorb it, and from these cells it passes on into the interior of the villi. After the food has passed into the villi, practically all the sugar, digested proteids, salts, and water that it contains pass at once through the thin walls of the capillaries, and mix with the blood that is already there. This part of our food then flows on into the veins and is conveyed by them to the heart.

The fat that has been absorbed into the villi passes into the

lacteals and on to the lymph tubes in the wall of the intestine. When digestion is not going on, the lymph in the lacteals and lymph tubes of the intestine is a watery fluid. But when the fine particles of fat from the food pass into the lacteals and mingle with the lymph, they give it a milky appearance. This milky fluid is no longer called lymph, but is called chyle. The chyle flows along the lymph tubes of the intestine into a larger tube called the thoracic duct. The contents of the thoracic duct pass into a large vein near the left side of the neck, and there mingle with the blood. (See page 107.)

The cells of the different parts of the body take from the blood the fats, proteids, sugar, salts, and water that they need, and use this material in different ways. The proteid part is used for repair of waste and for growth. The fats and carbohydrates are burned up in the cells, producing heat and power. Sometimes proteid also is burned up in the cells. This process is called oxidation. It takes place in most of the tissues of the body, but especially in the cells of the muscles and the glands, because these are the most active cells in the body.

As the sugar, salts, water, and digested proteids are going from the intestine to the heart they pass through the liver. During digestion more sugar is brought to the liver than is required for immediate use in the body. Part of this sugar is taken up by the liver cells, changed into a substance called *glycogen,* and stored in the cells until it is needed. When more sugar is needed by the cells of the body, the liver cells change the glycogen back into sugar and allow it to pass out into the

blood, and it also is oxidized in the cells of the tissues, giving out heat and power.

Effects of alcohol on the stomach.—Alcohol, like pepper, mustard, and other condiments, has a direct irritating effect on the mucous membrane that lines the stomach. It causes the small blood tubes in the lining to dilate and contain more blood than usual, and gives rise to a feeling of warmth in this organ. If only a small amount of alcohol is taken it is quickly absorbed into the blood tubes and carried away in the blood. The blood tubes remain dilated for a short time and then return to their usual size.

If alcoholic liquor is taken frequently, even in moderate quantity, the mucous lining of the stomach is constantly irritated, the blood tubes are kept dilated and congested, and the glands in the wall of the stomach pour out an increased amount of mucus. The mucus in a healthy stomach is a thin, watery fluid, and is secreted in small quantities in order to moisten the mucous lining. Under the irritating influence of alcohol an unhealthy, sticky mucus is secreted that coats the stomach wall. This unhealthy mucus greatly interferes with digestion, and frequently causes nausea and vomiting, especially in the morning. In later stages, patches of the mucous membrane may become so injured that they waste away and leave sores, or ulcers, in the wall of the stomach.

The large amount of fluid that is often taken by beer drinkers stretches the wall of the stomach and greatly increases the size of this organ. This stretching weakens the muscles in the wall

of the stomach so that food is not forced on into the intestine so promptly as it should be. This is a frequent cause of painful indigestion.

Effects of alcohol on the liver.—A large part of the alcohol that is swallowed is absorbed into the veins in the wall of the stomach, and is carried at once by the blood to the liver. Since it is the first organ to receive the alcohol after it enters the blood, the liver is greatly affected. On account of the irritating action of alcohol the blood tubes of the liver soon become dilated, and the whole organ becomes congested just as the blood tubes of the skin become congested when mustard is applied to it.

On those cells of the liver which secrete bile and store up glycogen, alcohol acts as a poison. At first these cells swell, and the liver becomes enlarged. If the action of the alcohol is continued for some time, the protoplasm of these liver cells changes more or less completely to fat, and the power of the cells to perform their work is greatly lessened.

The liver cells are held together by connective tissue. This tissue, as we have learned, is made up of cells with a large amount of intercellular material which is made by the cells. The connective tissue cells also of the liver are injured by the irritant action of alcohol. When a constant irritation is kept up, even by small amounts of alcohol passing through the liver, the connective tissue cells often increase in number. The new cells may develop into permanent connective tissue, taking the place of liver cells that have been destroyed, and also pushing aside and destroying other liver cells.

One function of the liver is to oxidize, and so render harmless, minute harmful substances in the blood. Some of these are due to the using up of proteid food in the process of nutrition; others may arise from various forms of disease. As blood containing such substances is passing through the liver, they are oxidized and thus prevented from injuring the tissues later. It has recently been discovered that even very moderate amounts of alcoholic liquor interfere to a marked degree with this important function of the liver.

SUMMARY

1. Food must be digested so that it can pass from the alimentary canal into blood tubes.
2. Digestion takes place in the mouth, the stomach, and the intestine.
3. In the mouth, food is torn apart by the teeth, and moistened and partly digested by the saliva.
4. The teeth should be kept clean, and cavities should be filled promptly.
5. Saliva contains a ferment, ptyalin, which can change starch to sugar.
6. Food should be well chewed and well mixed with saliva.
7. The epiglottis closes over the glottis when we swallow and prevents food from entering the windpipe.
8. Small glands in the mucous lining of the stomach secrete gastric juice.
9. This juice contains two ferments: pepsin, which digests proteid food, and rennet, which curdles milk.
10. Three digestive juices enter the intestine: pancreatic juice, bile, and intestinal juice.
11. Pancreatic juice can digest proteid, starch, and fat.
12. The bile aids pancreatic juice in digesting fat.
13. The intestinal juice acts upon cane-sugar and maltose.
14. The mucous lining of the small intestine has a large number of little projections called villi. These absorb from the intestine the part of our food that can be used in the cells of the body.

15. The proteid food, sugar, salts, and water go into the blood at once and then pass through the liver.

16. The fat goes into lymph tubes, on into the thoracic duct, and then into the blood.

17. Alcohol irritates the mucous lining of the stomach.

18. The continued irritation of the mucous lining causes an unhealthy secretion of mucus, and may cause sores or ulcers in the wall of the stomach.

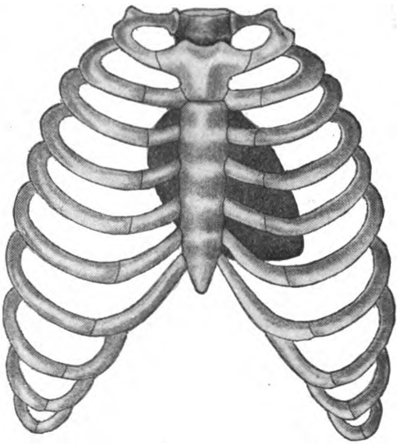
19. Alcohol injures the blood tubes and cells of the liver.

20. Alcohol interferes with oxidation in the liver, and harmful substances that should have been made harmless remain in the blood.

CHAPTER VIII

THE CIRCULATION OF THE BLOOD

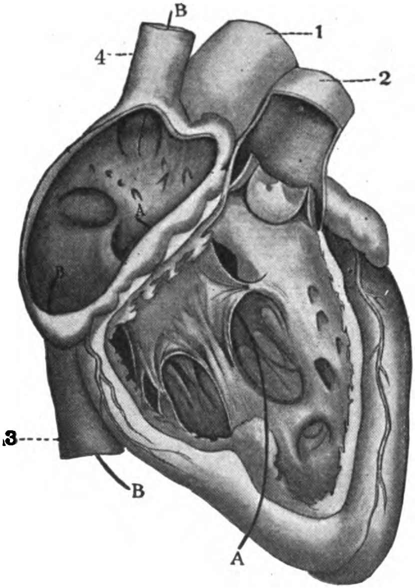
Uses of the blood.—The flow of blood throughout the body is called the circulation of the blood. As the blood flows through all parts it carries food and oxygen to the cells of the tissues. It distributes to all parts of the body the heat that is produced by the oxidation of food in the cells. If the skin, for example, were to receive no blood, it would soon become cold. While the blood is supplying food and oxygen to the cells of the tissues, it is also collecting waste matter from them and carrying it away to organs that expel it from the body. The heart, the arteries, the capillaries, and the veins are the organs that carry on the circulation of the blood.



THE HEART, RIBS AND STERNUM

What the heart is.—The heart is a hollow organ composed of muscle tissue. It is about the size of a man's closed fist, and has the shape of an inverted pear. As you will see from

the picture, the heart lies in the chest behind the ribs, but extends more to the left than to the right of the middle line. It is enclosed in a sac, called the *pericardium,* which is composed of *serous* membrane. This is a thin membrane that lines cavities of the body that do not communicate with the air. Serous membrane secretes a watery fluid that keeps its surface moist and slippery. The small end, or apex, of the heart points downward and toward the left; it lies within the thorax close to the chest wall.



INTERIOR OF RIGHT SIDE OF HEART
1. Aorta. 2. Pulmonary artery. 3. Inferior vena cava. 4. Superior vena cava.
From "Gray's Anatomy"

A partition, called the *septum,* divides the heart into a right and a left side. This partition completely separates one side from the other, so that no blood can get through.

Each side of the heart consists of two chambers, an upper and a lower one. The upper chambers are called *auricles* and the lower chambers are called *ventricles.*

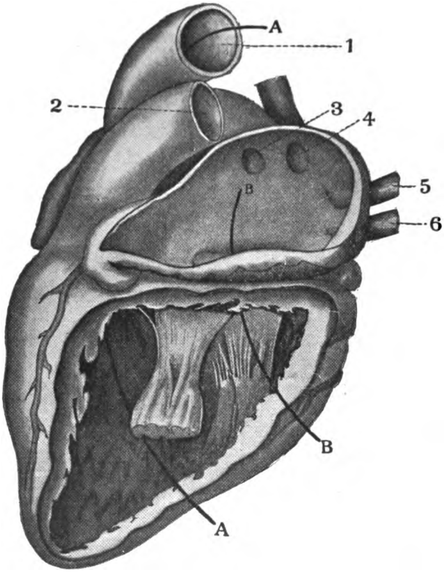
In this picture the outer wall of the right side of the heart has been removed so that you can see into the interior. Two large

veins open into the right auricle, and all the blood from every part of the body flows into the auricle through these veins. The wires marked B in the picture show how these veins open into the auricle. There is an opening through which the blood passes from the right auricle into the right ventricle. You can find this opening in the picture by a wire marked A that has been passed through it. A valve, like a little door, guards the opening. It is called the *tricuspid* valve, and consists of three segments, or flaps, the edges of which come together when it closes. As the ventricle becomes full of blood the valve closes and prevents the blood from flowing back into the auricle when the ventricle closes. Cords fastened to the flaps and to the sides of the ventricle prevent the flaps from being pushed out into the auricle as the blood in the ventricle presses against the flaps.

There is an opening through which the blood passes from the right ventricle into an artery called the pulmonary artery, which divides into two branches, one going to each lung. This artery can be seen at the right upper corner of the picture. Valves guard the opening into the pulmonary artery, and prevent blood from flowing back from the artery into the ventricle.

We have on page 94 a picture of the interior of the left side of the heart. Four veins, called pulmonary veins, open into the left auricle. In the picture these openings are shown by the figures 3, 4, 5, 6. There is an opening from the left auricle into the left ventricle. Its position is shown in the picture by a wire marked B. The valve that guards the opening, and prevents

blood from flowing back into the auricle, is called the *mitral* valve, because it looks like a mitre which a bishop wears on his head. There is an opening from the left ventricle into a very large artery, called the *aorta*. The position of this opening is shown in the picture by a wire marked A. Valves guard the opening into the aorta and prevent blood from flowing back into the ventricle.

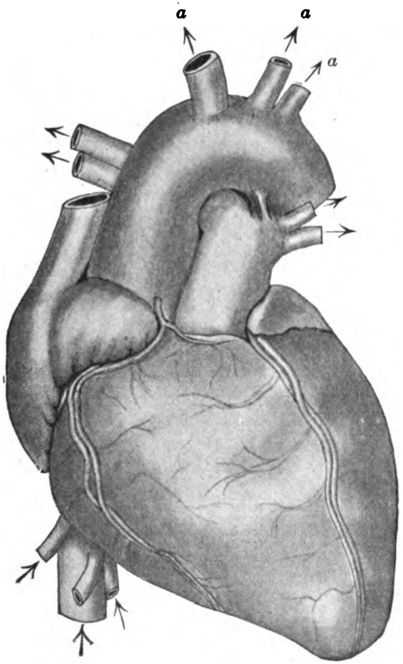


INTERIOR OF LEFT SIDE OF HEART
1. Aorta. 2. Pulmonary artery. 3, 4, 5, 6, Pulmonary veins
From "Gray's Anatomy"

This description, together with the pictures, will give you some idea of the heart, and what its important parts are. Let us now find out something about the arteries, the veins, and the capillaries. We shall then be ready to follow the course of the blood as it circulates through the body by means of all these organs.

The arteries.—The arteries are strong tubes, which are, as a rule, below the surface of the body, and are thus protected from injury. The wall of an artery contains tough elastic tissue and muscle tissue. In the wall of a small artery there is

a smaller proportion of elastic tissue and a larger proportion of muscle than in the wall of a large artery. The muscle fibres are wrapped around the artery at right angles to its length, very



HEART AND AORTA
a, a, a, Branches of Aorta

much as you would wrap a bandage around your finger. Muscles have the power to contract and become shorter. When these muscles contract they lessen the size of the artery just as squeezing it with your hand would lessen its size.

The aorta, which starts from the left ventricle, is the main artery of the body. It commences at the upper part of the left ventricle, ascends a little way, then bends over to the left behind the heart, so as to form an arch like a horseshoe. Then it passes through the thorax and abdomen, in front of the spine.

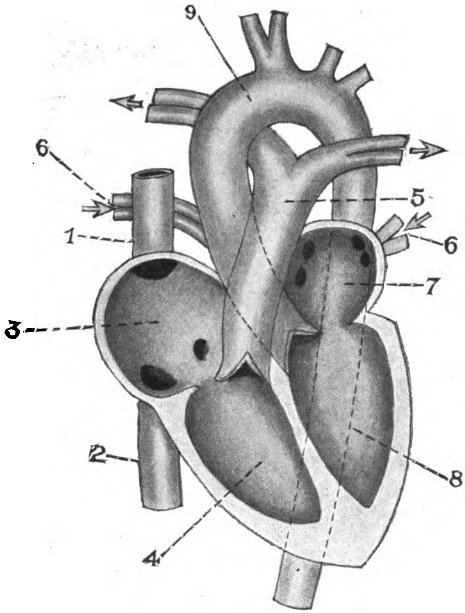
Beginning at a very short distance from the heart, branches are given off from the aorta throughout its entire length. Some of them pass upward to the neck and head; others pass outward to the arms and hands. Lower down, branches also pass off to the stomach, liver, kidneys, and other organs. One large branch goes to each leg.

All these branches of the aorta are called arteries, and as they pass out through the body they divide and subdivide many times. Each time they divide they become smaller and their walls become thinner.

The capillaries.—After the arteries divide many times, they become so small and so numerous that they form a fine network of hairlike tubes. The wall of each tube consists of a single layer of flattened cells, like little plates, joined at their edges. These tiny, thin tubes are no longer called arteries, but their name is changed to capillaries. With few exceptions, the cells of every tissue are surrounded by a network of capillaries so small that you cannot see them without a microscope, and having a wall that is much thinner than tissue paper.

The veins.—The tiny capillaries soon unite with one another to form larger tubes, and these unite again and again to form still larger ones, while at the same time their walls become

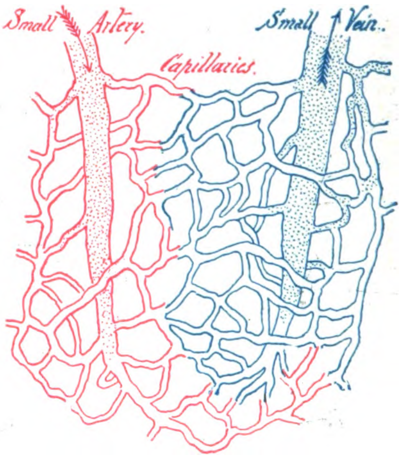
thicker. These larger tubes are called veins. They are at first only slightly larger than the capillaries; but as they continue to unite they form, each time, larger veins. The wall of a



SECTION OF HEART, SHOWING THE FOUR CAVITIES
1. Superior vena cava. 2. Inferior vena cava. 3. Right auricle. 4. Right ventricle. 5. Pulmonary artery. 6, 6. Pulmonary veins. 7. Left auricle. 8. Left ventricle. 9. Aorta

vein is thicker than the wall of a capillary, but it is thinner than the wall of an artery. It contains a smaller amount of elastic tissue and muscle. Most veins have valves that prevent the blood from flowing backward. A valve consists of a fold of the lining membrane of the vein.

You will see from what has preceded that there is only one set of blood tubes, but the different parts have different names. All the tubes that go from the heart out to all parts of the body are called arteries. All the tubes that go back to the heart

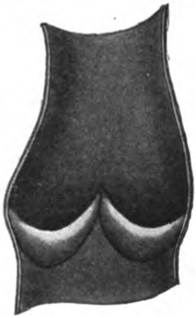


ARTERY, CAPILLARIES, AND VEIN
(Magnified)

are called veins. The little tubes that connect the arteries and veins are called capillaries.

Course of the blood.—The work of the heart is to receive the blood that is conveyed to it from all parts of the body through the veins, and immediately to force the blood out again to all parts of the body through the arteries. The walls of the heart are composed of muscles which contract, or shorten, and relax, or lengthen. When these muscles relax, the heart

chambers open and blood flows in from the veins. When these muscles contract, the chambers close and the blood is forced out into the arteries. The two auricles contract together, and immediately afterward the two ventricles contract together. Each time that the heart contracts, we say that it beats. By placing the hand on the chest, a little to the left side, you can feel every beat of the heart.



VALVE OF VEIN

Turn to the picture of the right side of the heart on page 92. Find the *superior vena cava*. These are Latin words for the upper hollow vein. It is through this vein that blood flows to the right auricle from the upper part of the body. Find the *inferior vena cava*. These are Latin words for the lower hollow vein. It is through this vein that blood flows to the right auricle from the lower part of the body. Find, by means of the wires, the opening from the vena cava superior and the vena cava inferior into the right auricle. When the right auricle opens, dark venous blood pours into it from the vena cava superior and from the vena cava inferior. Some of this blood runs on at once through the opening into the right ventricle. As soon as the auricle is filled, the blood in it is pressed into the ventricle.

The pulmonary circulation.—Before the blood is sent back to nourish the body it must get a supply of oxygen, and this can be obtained only from the air in the lungs. The flow of

the blood from the right side of the heart out to the lungs for oxygen and back again to the left side of the heart is called the pulmonary circulation. The artery through which the blood goes to the lungs is called the pulmonary artery. Find in the picture on page 92 the opening into this artery. It is through this opening that the blood is next forced by the contraction of the right ventricle. The pulmonary artery divides into two branches a little above the heart. One branch passes under the arch of the aorta and goes to the right lung. The other branch bends to the left and goes to the left lung. The dividing of the pulmonary artery continues until all the air sacs of the lungs are surrounded by a perfect network of tiny tubes—the lung capillaries. Through the thin walls of these capillaries the blood gets from the air in the lungs the oxygen that it needs. These tiny capillaries connect with small veins which lead back toward the heart. The small veins unite again and again until they form the pulmonary veins by which the blood enters the left side of the heart.

The systemic circulation.—The blood is now ready to carry both food and oxygen to all parts of the body. The flow of the blood from the left side of the heart out to all parts of the body and back again to the right side of the heart is called the systemic circulation. Turn to the picture of the left side of the heart on page 94. Find the openings from the pulmonary veins into the left auricle. As the bright arterial blood flows through these openings into the left auricle, some of it passes at once through the opening into the ventricle. The auricle,

however, is soon filled, and it then closes and presses its contents into the ventricle. Find the opening from the left ventricle into the aorta in the picture on page 94. It is through this opening that the blood is forced into the aorta by the contraction of the left ventricle. From the aorta the blood flows into the large aortic branches, then into the smaller arteries, and so on until it reaches the capillaries that surround the cells in the tissues of the body.

The blood as a whole does not leave the blood tubes. But while it is passing along the capillaries the oxygen and certain portions of the blood, which we may describe as the food, pass through the thin unbroken capillary wall, and fill the tiny spaces between the cells of the tissues. After it has passed through the capillary wall this fluid is called lymph. At the same time certain waste matter leaves the cells of the tissues and passes through the thin capillary wall into the blood. In the capillaries the blood loses its bright arterial color and becomes a dark bluish red. This is because it has given up its oxygen to the tissues. Laden with waste matter, it makes its way from the capillaries into small veins, thence to the larger veins, thence into the vena cava superior and the vena cava inferior, and back into the right side of the heart. The time taken by a drop of blood in making the entire circuit is probably about half a minute.

The portal circulation.—The blood from the blood tubes of the stomach and the intestine flows into a single vein called the portal vein. The portal vein enters the liver, and there

divides and subdivides into capillaries. These capillaries unite to form three veins which, on passing out of the liver, join the vena cava inferior. This flow of the blood through the portal vein to the liver and on through capillaries and veins into the vena cava inferior is called the portal circulation.

How the circulation may be affected.—The circulation of the blood may be hindered in many ways. Large veins lie just under the skin and near the surface. Tight clothing does not allow the blood to flow freely and easily through these veins. Tight boots make cold feet, because they interfere with the free flow of the blood. Tight garters, also, are a frequent cause of cold feet. The heart needs plenty of room in order to do its work well. Tight waists and other tight clothing press in the soft walls of the chest and interfere with the free action of the heart.

The pulse.—The pulse is caused by the beating of the heart. Each time the left ventricle contracts it forces a quantity of blood into the aorta. This blood strikes against the column of blood already in the aorta and starts a wave that travels along the blood in the arteries and causes the throb of the artery wall. This throb is called the pulse. It may be felt in any artery that is near the surface. A convenient place to feel it is at the wrist near the base of the thumb. It is because of this wave-like movement of blood along the arteries that it flows from a wounded artery in spurts; whereas, if a vein is wounded, blood flows from it in a steady stream.

The heart beats about seventy-two times a minute, but the

number of beats varies very much even in health. Active exercise, and such feelings as fear, surprise, or joy cause the heart to beat faster or slower than usual.

We count the pulse when we wish to know how fast the heart is beating. When a physician places his finger on an artery he is able to tell much about the strength of the heart, as well as the rapidity of its beat.

The health of the heart.—It must be plain to every one that it is most important to have a sound, healthy heart. If the heart is weak or the valves are imperfect, the blood cannot be discharged into the arteries with sufficient force to cause free circulation to all parts of the body.

Rheumatism is a frequent cause of heart disease, even in children and young people. In order to prevent this disease, as far as lies in our power, we should be careful not to live in damp houses. We should also avoid sitting on damp ground, and if our clothing becomes wet, we should change it without delay.

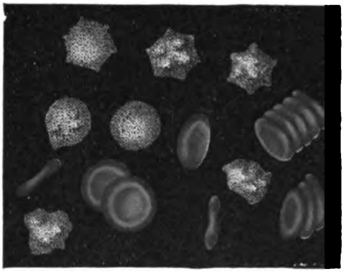
Excessive, violent muscular exercise is apt to dilate the heart and injure it. Persons that are feeble and delicate are more likely to be injured in this way than those that are strong and robust.

Bicycle riding in moderation is excellent exercise as a means of strengthening the heart, though when carried to excess it is a frequent cause of injury to it.

The blood.—Blood, as it flows from a cut or wound, is a red fluid. It looks to the naked eye as if it were composed of one

kind of material only; but, when it is examined with a microscope, it is found to consist of two materials: a watery fluid, the *plasma;* and little cells, the *corpuscles,* which float in the plasma.

The plasma.—The plasma is a transparent, almost colorless fluid. About ninety per cent. of it consists of water. The plasma contains proteids, sugar, salts, and fats derived from the food, and some waste matter from the tissues.



RED AND WHITE CORPUSCLES
(Magnified)

The corpuscles.—The corpuscles are extremely small bodies. This picture shows how they appear when seen through a microscope of high magnifying power. They are of two kinds, red and white. The white corpuscles are slightly larger than the red ones.

Three thousand five hundred red corpuscles placed side by side would make a row an inch long, and two thousand five hundred white corpuscles placed side by side would make a row of equal length. This will give you some idea of how the red and the white corpuscles compare in size.

The color of the blood is due entirely to the red corpuscles that it contains. Their use is to carry oxygen from the lungs to the tissues. These corpuscles float along in the blood stream of the arteries. When they reach the capillaries, oxygen escapes from the corpuscles and passes through the thin capillary

wall into the cells of the tissues. The red corpuscles then float back in the veins to the heart and go out to the lungs for more oxygen.

If a coin were hollowed out slightly on each side, its shape would be very much like the shape of a red corpuscle.

There are immense numbers of these corpuscles in the blood. A drop of the blood of an average healthy man contains about five million red corpuscles.

The white corpuscles are less numerous than the red. There are about five hundred red corpuscles for each white one. The white corpuscles have a peculiar power of movement by which they are able to alter their shape. At times they are spherical; at other times they thrust out an arm-like projection in one direction, or several projections in different directions, and their shape becomes extremely irregular.

These corpuscles are able to pass through the walls of the capillaries and wander about in the neighboring tissues. When any part of the body has been wounded, they collect around the wound and prevent bacteria and other injurious matter from entering the blood. The white corpuscles often succeed in destroying and removing bacteria in a wound, but sometimes they are beaten in the battle and are themselves destroyed. Then they form a part of the pus that flows from the wound. They also serve to protect the body from the invasion of germs that produce disease, and they assist in the clotting of blood.

How the supply of blood to organs is regulated.—The blood stream carries food and oxygen to all parts of the body.

Oxygen is carried by the red blood corpuscles; food is dissolved in the plasma and is carried by it.

The amount of blood required by any organ is not the same at all times. When an organ is actively at work, it requires a greater supply of blood because it needs more nourishment; but when an organ is at rest, or is less active, it needs less blood.

When food enters the mouth, the salivary glands become more active. They pour out an increased amount of saliva; and, at the same time, the small arteries in these glands dilate and allow an increased amount of blood to come to these organs.

When the stomach must get ready to digest food, it requires more blood to help do its work. The muscles in the small arteries in the wall of the stomach relax; and, as the arteries dilate, more blood comes to the stomach.

As we go to sleep the brain becomes less active than when we are awake. During sleep the blood tubes in other parts of the body dilate and contain more blood than usual, so that less blood comes to the brain when it is at rest.

The muscles in the walls of the small arteries are connected by nerves with the brain and spinal cord. Messages, without our knowing it, pass along these nerves when required, causing the muscles to contract and lessen the size of the arteries. So long as the messages continue to come to the muscles they remain contracted, and the arteries contain less blood. If the messages are few, or cease entirely to come, the arteries become dilated and contain more blood. In this way the supply of blood to different parts of the body is continually regulated by

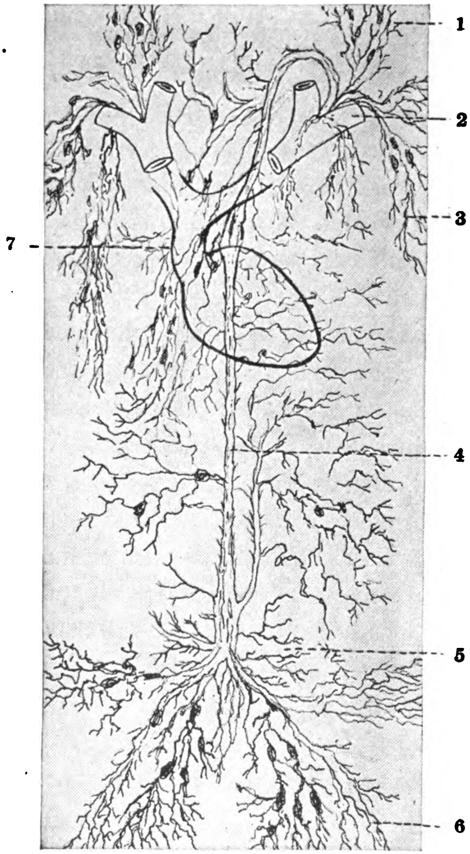
nerves. More blood comes to any given part when it is active, and less blood when the part is not active.

Clotting of blood.—Blood is perfectly fluid when it first escapes from a cut or wound. It soon, however, becomes sticky and in five or ten minutes changes to a jelly-like mass. The mass, in a short time, contracts and becomes much smaller. It is then called a clot. While the mass is contracting an almost colorless fluid, the serum, is squeezed out, and the clot floats in this serum.

Clotting of blood is caused by a change in a part of the plasma by which fibrin is formed. When a clot is examined with a microscope it is seen to consist of corpuscles enclosed in a tangled mass of fine hair-like fibrils of fibrin. While the fibrils are being formed they entangle the corpuscles, as in a spider's web, and then form the clot. A clot forms because of changes that take place in the blood itself, and not because it is exposed to the air. Fibrin may be obtained by whipping fresh blood with a bunch of little twigs. The fibrin will adhere to the twigs in the form of tiny threads, or fibrils.

The use of the clot is to stop bleeding. It acts as a plug and prevents the escape of blood from a torn or cut blood tube; when the tube stops bleeding one should be very careful not to disturb the clot.

The lymph tubes and the thoracic duct.—In the tissues of the body there is a system of tubes that are quite distinct from the blood tubes. They contain a colorless watery fluid called lymph, and are called lymph or lymphatic tubes.

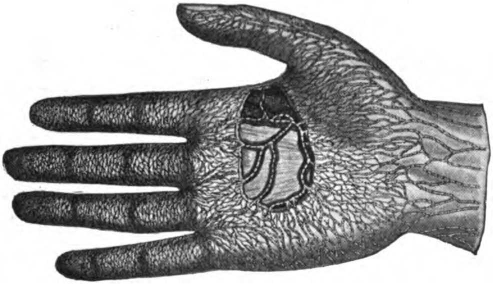


THORACIC DUCT AND LYMPH TUBES

1. Lymph tubes of head and neck, left side. 2. Veins of left shoulder. 3. Lymph tubes of left arm. 4. Thoracic duct. 5. Lymph tubes of intestine, called lacteals. 6. Lymph tubes of left leg. 7. Vena cava superior

The following pictures show some of the lymph tubes of the hand and of the arm and trunk. You can see how the smaller tubes unite to form larger ones. The current of lymph in the tubes is always toward the heart.

The lymph contained in the lymph tubes is derived from the blood. While the blood is flowing through the capillaries in

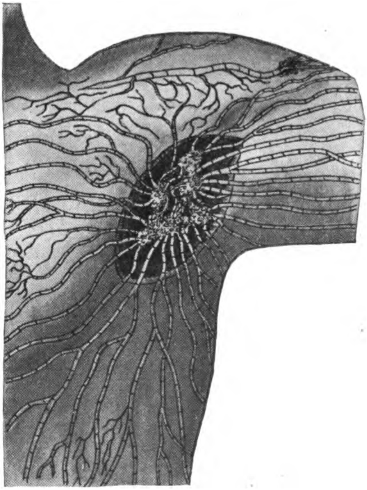


LYMPH TUBES OF HAND

the various parts of the body, some of the plasma of the blood oozes out through the thin capillary walls into the tiny spaces between the cells of the surrounding tissues. After this watery part has oozed through the capillary walls it is called lymph. Some of the lymph, after bathing the cells of the tissues, and giving up nourishment to them, may pass back into the capillaries, but a large part of it enters the lymph tubes, which are specially provided for it.

These tubes start from the little spaces between the cells, and unite again and again to form larger tubes. The picture on page 108 shows how the small lymph tubes of the lower part of the body,

the intestine, and the left side of the upper part of the body pour their contents into a larger tube called the thoracic duct. This duct ascends in front of the spinal column and pours its contents, consisting of mingled chyle from the intestine and lymph, into a vein of the left shoulder, at a point where this vein joins a vein from the neck. Here the contents of the thoracic duct join the blood stream as it is on its way to the vena cava superior, a short, large vein formed by the junction of two veins, and to the right auricle of the heart. Another set of lymph tubes collect lymph from the right side of the upper part of the body, and pour it into a vein of the right shoulder, at a point where this vein joins a vein from the neck. Here the lymph joins the blood stream as it is on its way to the vena cava superior and the right auricle of the heart.



LYMPH TUBES OF ARMS AND TRUNK

Effects of alcohol on the circulation.—A moderate amount of alcohol causes the heart to beat faster for a short time, and the pulse becomes fuller. The fuller pulse may give a false impression and lead to the belief that alcohol stimulates the heart and makes it beat with greater force. The change in the pulse

is due to the fact that alcohol causes the small arteries throughout the body to dilate. The large bounding pulse, which gives a deceptive appearance of vigor and force in the circulation is due to the change in size of the dilated arteries.

There is no evidence that alcohol acts as a direct stimulant to the heart, or that it causes the heart to beat with greater force. In small quantities its action on the heart is slight, but in large amounts it has a powerful effect in depressing the heart and weakening the force of its beat.

The long continued use of alcoholic liquors, especially of beer, often leads to an increase of fat in the muscle fibres of the heart, and also between them. As the heart thus becomes weakened it becomes larger and less able to perform its work well. The so-called "beer-drinker's heart" is larger than it should be, and has an unusual amount of fat on its surface as well as in its muscle fibres and between them. It is a heart that is liable to fail when an unusual strain, as in disease, is put upon it.

The continued drinking of alcoholic liquors often causes permanent changes in the walls of the blood tubes. The walls become thickened and less elastic. They may also be further weakened by fat in their muscles. This diseased condition of the blood tubes interferes very seriously with the circulation of blood and nourishment of the body.

Soon after the Olympian games in the spring of 1906 the following cable despatch appeared in the New York *Sun*: "Berlin, May 19.—German writers, in commenting on the failure of German athletes to carry off signal honors in the

Olympian games at Athens, assert emphatically that the chief cause of the low standard of their physical achievements is the beer-drinking habit, which is greatly sapping the national vigor.

"Several writers agree that this habit prevents the Germans from acquiring that tautness of muscle which distinguishes the American and English athletes, and not only causes superfluous fat but seriously affects the heart, which is the sport organ *par excellence.*"

On this point it is well to remember the words of the late General von Moltke, Commander of the German army: "Beer is a far more dangerous enemy to Germany than all the armies of France."

The following statements from American athletes who were winners in the Olympian games at London in 1908, show the practice of many athletes in this country in regard to the drinking of alcoholic liquors:

BAYONNE, N. J., *December* 30, 1908.

Dear Sir:—In reply to your letter of the 18th inst. requesting a statement as to the effect of alcoholic liquors and tobacco, I can say that my experience of eighteen years has shown me that alcoholic liquors and tobacco should not be used during periods of training. If this abstinence keeps the body in the best condition for feats of strength, it certainly shows that, if we want to live a long healthy life, we should leave alcohol and tobacco alone.

Yours truly,

RAY C. EWRY,

(*Champion, Standing High Jump, and Standing Broad Jump.*)

CLEVELAND, OHIO, *January* 27, 1909.

Dear Sir:—As an athlete throughout my school-day career and since, I have always found it wise to abstain from the use of narcotics and alcoholics.

Faithfully yours,

HARRY FRANKLIN PORTER,

(*Champion, Running High Jump.*)

NEW YORK, *January* 24, 1909.

Dear Sir:—From a competitor's stand-point, athletes in training for different events greatly retard progress in conditioning themselves by the use of alcoholic beverages or tobacco in any form, as their use affects one's staying powers—particularly for gruelling contests.

Yours truly,

HARRY HILLMAN,

(400 *Meters Hurdle.*)

SUMMARY

1. The blood carries food and oxygen to the cells.
2. The blood distributes heat to all parts of the body.
3. The blood collects waste matter from the cells and carries it away.
4. The work of the heart is to receive blood from all parts of the body and to force it out again to all parts.
5. From the right side of the heart blood goes to the lungs, and then to the left side of the heart. This is called the pulmonary circulation.
6. From the left side of the heart blood goes out to all parts of the body, and then back to the right side of the heart. This is called the systemic circulation.
7. The flow of blood from the stomach and intestine through the liver is called the portal circulation.
8. The circulation of blood should not be hindered by tight clothing.
9. The pulse is the throb in the wall of an artery because the heart has forced more blood into it.

10. The heart may be injured by rheumatism and by excessive violent exercise.

11. The blood consists of the plasma and the corpuscles.

12. The plasma conveys food in solution; the red corpuscles convey oxygen.

13. The white corpuscles destroy bacteria and assist in the clotting of blood.

14. When blood escapes from a blood tube it clots. The use of the clot is to stop bleeding.

15. Plasma is called lymph after it passes through the walls of the capillaries to carry food to the cells.

16. Much of the lymph is returned to the blood by means of the lymph tubes. The largest of these is the thoracic duct.

17. In moderate amounts, alcohol does not strengthen the heart. In large amounts, it weakens the heart.

18. The continued drinking of alcoholic liquor, especially beer and wine, may cause an increase of fat in and also between the fibres of the heart.

19. The continued drinking of alcoholic liquor may injure the walls of the blood tubes.

CHAPTER IX

IS ALCOHOL A FOOD?

We have learned that when alcohol enters the stomach it passes into the small veins in the wall of the stomach and mingles with the blood. It is then conveyed in the blood to the cells of tissues in different parts of the body just as food is conveyed to the cells. But when it reaches the cells, its action differs in important ways from the action of ordinary foods.

The purposes of food are to build up and repair the tissues, and to serve as fuel.

Only those foods which contain nitrogen, viz., proteid foods, can build up and repair the tissues. Alcohol does not contain nitrogen, and therefore cannot replace the worn-out substance of cells or build up new tissue in the body. Alcohol, then, is not a food in the sense that meat, eggs, gluten, and other proteids are food.

Food is also the fuel of the body, and it is burned, or oxidized, in the cells of the tissues by uniting with oxygen just as truly as coal is burned in a furnace. When food is oxidized in the cells of the tissues, heat and power to work are produced. Sugar, starch, and fats are examples of foods that are useful as fuel. Such foods may be oxidized in a very short time after they reach the cells of the tissues, or they may be stored up for future use.

Experiments show that when a small amount of alcohol is taken into the body, nearly all of it is oxidized in the cells of the tissues. It is, however, always oxidized in a short time after it reaches the tissues, and is never stored up for future use. In this respect alcohol differs from starch, sugar, and other fuel foods.

When a small amount of alcohol is taken it is oxidized in the cells of the tissues, and heat and power to work are produced. Consequently, alcohol in small amounts acts in one way like a fuel food. But the mere fact that a substance is oxidized in the cells of the tissues does not show whether it is useful or harmful to the body.

If alcohol is useful as a fuel food it ought to protect the body against cold. It should also add strength to the muscles and enable those who take it to do an increased amount of work. But the experience of officers in the army, of athletes, and of those who employ men in factories, on railroads, and in other laborious occupations, shows that men can do more and better work when they do not take alcoholic liquor than they can when they drink such liquor even in moderate amounts. The experience of explorers and lumbermen in the far north shows also that the drinking of alcoholic liquor is useless to protect the body against cold. It has been found that in those occupations requiring close attention, keen senses, clear judgment, and steady nerves, the use of alcoholic liquor of any kind is always injurious.

The chief reason why alcohol does not strengthen the mus-

cles and enable those who drink it to do an increased amount of work is because of its action as a drug. This is the most important difference between alcohol and substances that are usually called foods. The chief effect of food is to nourish and strengthen the body; the most important effect of alcohol is its action as a drug on the brain and nerves.

Men, as a rule, do not take alcoholic liquor as food, but for the peculiar effect it produces on the brain.

Suitable quantities of ordinary food are harmless to the tissues, and are absolutely necessary to maintain the body in a state of health. Alcohol is not necessary to a healthy body under any conditions or in any amount.

Alcohol, then, is not a food in the ordinary sense in which we use that term, but it belongs to a class of dangerous drugs called narcotics. Its action resembles the action of such drugs as ether and chloroform.

Poisonous action of alcohol.—The action of alcohol as a narcotic poison is plainly seen in the condition of intoxication that follows the drinking of large amounts of alcoholic liquor. The thickened speech, staggering gait, drowsiness, and loss of consciousness in this condition are caused by the alcohol. In such cases it acts on the brain as a poison.

Its poisonous action is plainly shown also by the changes that occur in the cells of the brain and other organs when the free indulgence in alcoholic liquor is continued for some time. Such changes lead, sooner or later, to disease in the organs affected. These diseases due to the drinking of alcohol some-

times occur in persons who never drink alcoholic liquor in quantities sufficient to cause intoxication.

The continued use of alcoholic liquors in moderate quantities does not affect all persons in the same way, or to the same extent. Some persons are more readily injured by it than others. In the case of some persons, the moderate use of alcoholic liquor as an occasional beverage with meals does not apparently shorten life or cause sufficient changes in any organ to produce disease that can be recognized. In the case of others, such moderate use produces gradual and permanent changes in internal organs, such as the heart, liver, and kidneys. These changes, as a rule, come on slowly and are not easily recognized at first, but gradually they tend to weaken the organs and injure the general health.

The appetite for alcohol.—The chief danger in drinking an occasional glass of wine, beer, or other alcoholic liquor is not on account of any immediate harm that it may produce in the organs of the body. The great danger is in the tendency gradually to increase the amount as the body becomes accustomed to its use. Most people are apt to overestimate their power to resist this growing appetite for alcoholic liquor. The habit of drinking often fastens itself upon a man before he realizes that the habit is formed; and, when he finds it out, the habit has often become so strong that it does not seem possible to give it up. It is because the appetite for alcohol grows on one that many who begin as occasional or moderate drinkers, and intend to remain such, become, in time, hopeless drunk-

ards. Any kind of alcoholic liquor may cause this unnatural and uncontrollable appetite for alcohol.

While it is true that some persons continue for years to drink small amounts of alcoholic liquor without apparent injury, it is also true that no one can be sure in advance that, if he commences as a moderate drinker, the habit will not grow upon him until he becomes a confirmed drunkard. The only safe course, therefore, is not to drink alcoholic liquor at all.

A recent American medical work on poisons contains this statement regarding alcohol: "From almost every stand-point alcohol must be regarded as the most important poison with which medical men and jurists have to deal; no other poison causes so many deaths or leads to or intensifies so many diseases, both physical and mental, as does alcohol in the various forms in which it is taken."—*Text-book of Legal Medicine and Toxicology*, Peterson and Haines, Vol. II, page 537.

The following quotations are from a pamphlet on alcohol that is given to every young soldier and sailor on joining the German army or navy:

"Alcoholic drinks do not quench the thirst so well as water, tea, coffee, and lemonade, and they contain no nutriment, or at least very little. Thus a glass of heavy beer, for which five cents are paid, has no more nutriment than a piece of cheese that costs a quarter of a cent. To give beer the name of liquid bread is, therefore, not at all justifiable."

"We may say that almost all brawls and cases of disorderly conduct are to be traced back to intoxication. And in most cases—

which must be noted here very clearly—it is the beer that does so much harm. Beer is, therefore, by no means the harmless drink that so many consider it to be."

"The military authorities adopt many measures in order to abate intemperance. Among these, there is an order that, on marches, field flasks shall be filled with non-alcoholic drinks; and there is strict supervision in regard to this rule."

Before the days of modern machinery, each man began and completed a piece of work himself. If he was not in condition for turning out his best work, it was only his work that was spoiled or delayed. In these days, however, a number of men are employed on the same piece of work, each at his machine doing a small part of it. In order that work may be completed without delay, and may be done in the best manner possible, each man must be always in condition to turn out his best work. It is not surprising, therefore, that many large employers discourage and even prohibit the drinking of alcoholic liquors by employees. The letters that follow illustrate the stand that many employers take in this matter.

BOSTON, MASS., *January* 25, 1909.

Dear Sir:—Yours of January 22d has been duly received, and in reply to the same I will say, that for more than half a century it has been the policy of our house not only to discourage the use of alcohol by our employees, but it has been also absolutely prohibited during working hours. Our work necessitates specially trained mechanics of the highest class. These men remain with us usually for very many years, sons following father not infrequently in employment in our factories. We do not presume to be the censor

of any man's conscience, or what he shall eat or drink, but we do not knowingly engage any man who indulges in the use of alcohol, because he would fail to remain with us for any length of time.

Very truly yours,

MASON & HAMLIN CO.,

A. W. Wright, *Vice-Pres. and Gen. Mgr.*

BOSTON, MASS., *January* 25, 1909.

Dear Sir:—In reply to your letter of the 22d inst., we would say that we discourage, so far as we possibly can, the use of alcoholic liquors by all our employees. We are especially strict against the use of alcoholic liquors by employees having positions of responsibility.

Yours truly,

THE BOSTON BRIDGE WORKS, INC.

MANCHESTER, N. H., *February* 19, 1909.

Dear Sir:—Replying to your letter of recent date, I beg to advise that we do not allow the employees of any of the lighting or railway companies that we own to use alcoholic liquors while on dutv.

Very truly yours,

J. BRODIE SMITH,

Vice-Pres. and Gen. Mgr.

Manchester Traction, Light and Power Co.

PITTSBURG, PA., *January* 11, 1909.

Dear Sir:—Replying to your letter of the 4th inst., I beg to advise that the only rule which this company has in effect with reference to the use of alcohol, is as follows:

"Employ steady, reliable, sober men *only*, in the capacity of mine foreman, fire boss, master mechanic, hoisting engineer, boiler and fan tenders, and stable boss; the use of intoxicating liquors by any employee while on duty is absolutely forbidden, and no

employee will be allowed on the plant or permitted to enter the mine visibly under the influence of liquor."

Yours very truly,

H. C. Frick Coke Company,

D. H. Coble, *Secretary*.

SUMMARY

1. Alcohol cannot replace worn-out matter in the cells or build up new tissue.
2. Carbohydrate food may be oxidized in a short time in the cells, or it may be stored up in them for future use.
3. Taken in small amounts, alcohol is oxidized in the cells; but it is oxidized in a short time. It is not stored up.
4. The fact that a small amount of alcohol is oxidized in the cells, yielding heat and power to work, does not prove that it is a useful food.
5. Alcohol does not add strength to the muscles.
6. Alcohol does not protect the body against cold in severe climates.
7. Alcohol is usually taken because of its effect as a drug on the brain and nerves.
8. Alcohol should be classed as a narcotic poison.
9. Its action as a poison is clearly seen in intoxication.
10. It often produces in the cells of the brain and other organs serious changes that in time cause disease.
11. The greatest danger in the moderate drinking of alcohol is that it may lead to an uncontrollable appetite for alcohol.

CHAPTER X

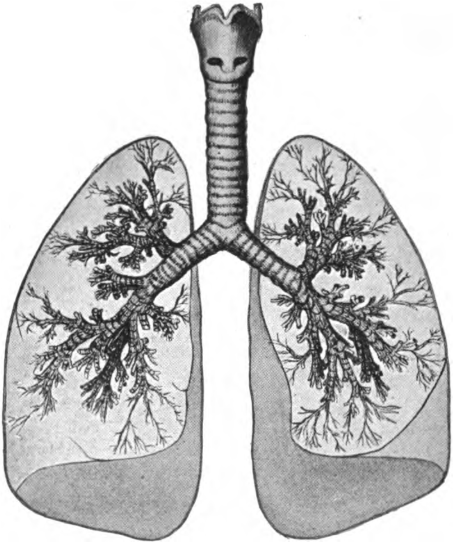
BREATHING

Air.—Air is a mixture of gases. It is composed of a large amount of oxygen and nitrogen and a small amount of carbon dioxide and other gases. For animals the necessary gas in pure air is oxygen. They must have oxygen in order to live. Man can live a month without food; a few days without water; but only a few minutes without oxygen. We breathe on an average about eighteen times a minute. Oxygen enters the body with every breath.

Some of the oxygen that we breathe in with the air enters the blood and is carried to the cells of the tissues, where it is used to oxidize the food. The oxygen, however, does not all pass into the blood, for the supply in pure air is so great, that, under ordinary circumstances, we require only about one-fifth of the amount that we take in. The remaining four-fifths are carried out again.

The windpipe and the air tubes.—Air enters through the nostrils or mouth, then passes down through the windpipe, or trachea, into the lungs. The trachea divides at its lower end into a branch for each lung. On page 124 there is a picture of the trachea and its branches, together with an outline of each lung. The trachea begins at the larynx, or Adam's apple.

The trachea varies from four to four and a half inches in length and is about three-quarters of an inch in diameter. Each of its branches, as you see in the picture, divides and sub-

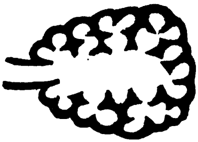


TRACHEA AND ITS BRANCHES

divides many times, forming the bronchial tubes. The bronchial tubes continue to divide and give off branches which become smaller and smaller until they end in tiny air sacs, composed of thin elastic tissue. Several air sacs are often grouped around the end of one small bronchial tube.

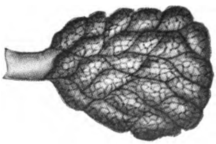
Spasmodic croup.—This is an ailment that is common among little children. The child goes to bed well, and about midnight awakens with difficult breathing and a crowing cough.

The condition often appears very serious and causes great alarm, owing to the suddenness of the attack and the distress from difficulty in breathing. These attacks are usually caused by a spasm, or cramp, in the muscles of the larynx, and are seldom serious. A large handkerchief wrung out of hot water and applied to the neck in front is usually sufficient to relieve the spasm in a short time.



SECTION OF GROUP OF AIR SACS AT END OF SMALL BRONCHIAL TUBE

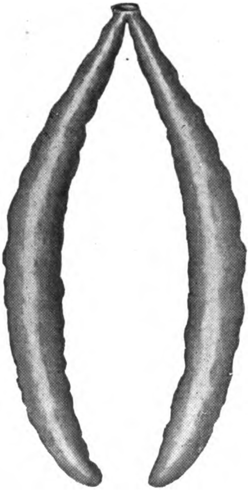
Membranous croup.—In the disease called diphtheria a thin, grayish-white membrane usually forms on the tonsils and other parts of the throat. Sometimes a similar membrane forms in the larynx, and gives rise to a very serious condition known as laryngeal diphtheria, or membranous croup. The disease begins with slight hoarseness and a croupy cough, which gradually becomes more severe. The membrane increases in thickness and soon fills the interior of the larynx, so that during respiration air passes in and out with great difficulty. Unless relief is obtained, suffocation quickly follows. The larynx can be kept open by means of a small tube which is put into it through the mouth.



GROUP OF AIR SACS AT END OF SMALL BRONCHIAL TUBE, SHOWING CAPILLARIES IN WALLS OF SACS

Asthma.—Asthma is a disease in which there are paroxysms, or spells of difficult breathing. The attacks often come on in the night after a few hours of sleep. There is then a painful sense of want of breath, a

feeling of great oppression in the chest, and a desire to sit upright in order to get relief. The attack may pass off in a short time or may continue on and off for a few days. During the paroxysms remove all tight clothing and allow an abundance of fresh air.



THE LUNGS OF A NEWT

Pneumonia.—Pneumonia is a disease in which there is a local inflammation in the lung. It is one of the most common of all acute diseases, and occurs equally in cold and in hot countries. People who live in cities and those who are exposed to hardship and cold are the most liable to have it.

A simple kind of lung.—The lungs of animals are not all alike. In some the structure is more simple than in others. It will help us to understand what our lungs are like if we first learn the structure of more simple lungs, such as are found in the newt, a little animal that somewhat resembles a lizard.

A newt's lungs consist of two oval sacs and a very short windpipe. They resemble in some ways small toy balloons. The wall of a toy balloon is elastic. It swells out when the balloon is inflated and collapses when the air goes out of it. The wall also of the sac that forms a newt's lung is elastic. When the newt breathes in, its lungs swell out and become larger. When it breathes out, its lungs shrink and become smaller again,

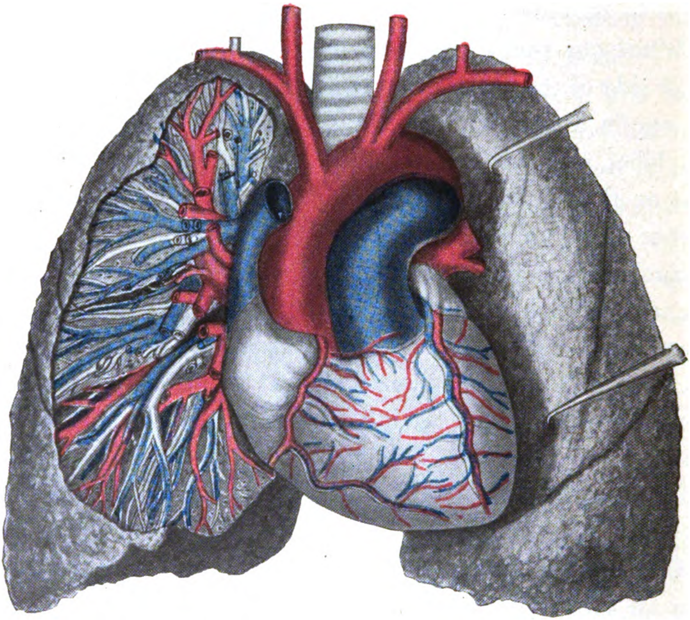
but the little sacs are never quite empty. They always contain some air. Tiny capillaries are fitted into the wall of each air sac, and form connecting links between the arteries and the veins in the sacs.

What our lungs are like.—We have two lungs, one in the right side of the chest and one in the left. They are soft and spongy in texture and light pink in color. The left lung has two lobes, or divisions, and the right lung has three. The lungs rest on the broad, tough muscle called the diaphragm, which arches up into a sort of dome, and supports them.

Each lung is covered with a smooth, delicate serous membrane called the *pleura*. The chest also is lined with it. Serous membrane, you remember, secretes a watery fluid that keeps its surface moist and slippery, so that though the pleura that covers the lung rubs against the pleura that lines the chest, there is no friction. You may have heard of a disease called pleurisy. It is the name given to an inflammation of a pleura.

In our lungs there are more than eight hundred millions of tiny air sacs, and each one resembles the small sac that makes up one of the lungs of a newt. These air sacs are arranged around the ends of the bronchial tubes, so that the air which is breathed in passes along the bronchial tubes into the air sacs at their ends. Each sac is composed of thin elastic tissue with capillaries embedded in its wall (see cut on page 125). These capillaries are the connecting links between the arteries and the veins in the lungs.

Here is a picture of the lungs and heart. A portion of the right lung has been removed so that you can see the arteries, veins, and bronchial tubes within it.



LUNGS AND HEART. PART OF LUNG CUT AWAY FROM LEFT SIDE TO SHOW BLOOD TUBES AND AIR TUBES

Movements in breathing.—The act of breathing consists of two movements. We breathe in and we breathe out. When we breathe in, we are said to inhale, or inspire; when we breathe out, we are said to exhale, or expire.

In breathing, the chest acts like a pair of bellows. When the

handles of a pair of bellows are drawn apart the sides are separated so that the cavity between them is enlarged, and air immediately passes in to fill the space.

When you take a deep breath you simply enlarge the cavity, or holding capacity, of the chest, and the lungs expand to fill the increased space around them. When the lungs expand, each air sac becomes larger, and air passes in to fill the increased space.

The expansion of the chest is due to the action of certain muscles. If you place your hands on your chest while breathing deeply, you can feel the wall of the chest moving. The muscles in the wall of the chest contract, so as to raise the ribs and breast-bone and cause them to move outward. At the same time the diaphragm, which forms the floor on which the lungs rest, contracts. This lowers the floor and more space is left for the lungs. In this way the capacity of the chest is increased in all directions.

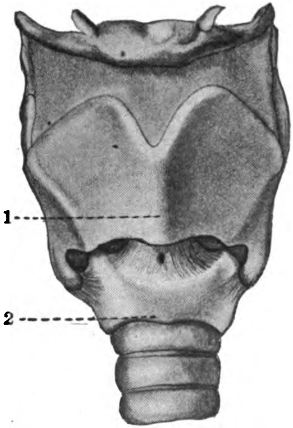
During expiration the muscles relax, and the diaphragm, the ribs, and the breast-bone return to their former positions. As the chest thus becomes smaller, its wall presses on the lungs and expels a portion of the air they contain.

In quiet, ordinary breathing, about one-sixth or one-seventh of the air in the lungs is expelled at each expiration.

Mouth breathing.—Air should always enter the lungs by way of the nostrils, because the nasal passages are so constructed that they delay the air within them long enough to strain dust from it, warm it, and moisten it, if it is too dry. A person that

makes a habit of breathing through the mouth is more likely to have lung diseases than one that breathes through the nose.

Sometimes nose breathing is made difficult by little grape-like clusters in the back part of the nasal passages. They are called adenoid growths, and should be removed by a doctor; for, besides interfering with breathing, they may cause defective hearing.



THE LARYNX
1. Thyroid cartilage. 2. Cricoid cartilage

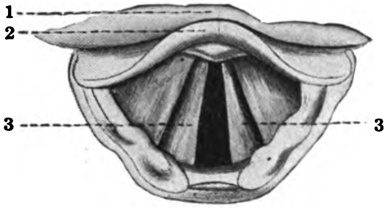
Breathing exercises.—Breathing exercises strengthen the muscles of the chest and increase the capacity of the lungs. They are especially desirable for those who have narrow, contracted chests, and also for those who, because of delicate health, cannot safely take part in active, vigorous games.

The voice.—All sound is produced by vibration, or rapid movement to and fro, of the air. In the case of the voice this vibration is produced by means of the vocal cords. The vocal cords are contained in the *larynx*, a box-like structure placed at the upper end of the windpipe. The walls of the larynx are composed of cartilage.

This picture shows the front part of the outside of the larynx. The broad upper part, in which a deep notch is seen in front, is the *thyroid* cartilage. It forms a complete ring around the upper part of the windpipe. The thyroid cartilage rests on the

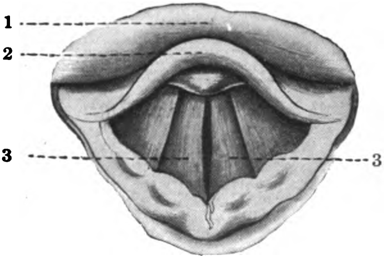
cricoid cartilage, and the projecting part of the thyroid just below the notch is sometimes called "Adam's apple."

With the mouth wide open and the tongue drawn well forward, it is possible to see an image of the vocal cords in a small mirror held at the back of the throat. This picture represents a view of the vocal cords obtained in this way, and shows the inside of the larynx. 1 represents the root of the tongue just above the larynx, and 2 the epiglottis, which folds over and covers the opening into the larynx when we swallow. The two bands, 3 3, represent the vocal cords. The opening between them is called the glottis.



THE VOCAL CORDS IN QUIET BREATHING

During quiet breathing the vocal cords lie apart and the glottis is wide. While we are speaking or singing, the vocal cords come close together and the glottis is narrow, as is shown in the picture.



THE VOCAL CORDS IN SPEAKING OR SINGING

When the vocal cords are brought together they are made tense by the contraction of muscles in the larynx. Then, as a blast of expired air passes through the narrow glottis, it causes the tense vocal cords to

vibrate. The vibrations of the cords make vibrations in the air, which reach the ear and produce the sensations of sound.

Exchange between blood and air in the lungs.—We have called the capillaries embedded in the walls of the air sacs the connecting links between the arteries and the veins in the lungs. To these tiny capillaries, branches of the pulmonary artery convey dark red venous blood from the right side of the heart to receive oxygen from the air in the air sacs; and from these capillaries branches of the pulmonary veins convey bright red blood, containing a fresh supply of oxygen, to the left side of the heart. Do not, however, get the idea that the blood and the air mix in the air sacs. They are always separated by the thin walls of the capillaries and the air sacs. But the oxygen passes through these walls into the blood. The moment the oxygen reaches the dark red corpuscles of the venous blood it changes them to a bright red.

The purpose of breathing is not only to get a fresh supply of oxygen into the blood through the lungs, but also to allow carbon dioxide to escape from the blood through the lungs. While the blood is flowing along the lung capillaries and taking in a new supply of oxygen, some of the carbon dioxide in the blood goes through the walls of the capillaries and air sacs, mingles with the air in the lungs, and is breathed out.

Thus, you see, there is an exchange between the air and the blood in the lungs. *Oxygen goes from the air to the blood, and carbon dioxide goes from the blood to the air.*

The air we breathe out is said to contain, also, a small amount

of poisonous animal matter. Except on a very hot day, expired air is warmer than inspired air, and contains more moisture. You can see this moisture in the form of watery vapor if you will breathe on a cold mirror.

It is often said that the blood is purified in the lungs; but the lungs remove only a part of one of the impurities that the blood contains, viz., carbon dioxide. Other organs, the skin and the kidneys, remove a part of other impurities contained in the blood. The blood always contains some impurities; but, when the body is in a state of health, these impurities are kept from accumulating in the blood in sufficient amount to do harm.

How blood is changed in the tissues of the body.—The bright arterial blood, you remember, is sent out from the left side of the heart, through the aorta and its branches—the arteries—on to the capillaries of the tissues throughout the body.

While the blood is flowing along the capillaries of the tissues, oxygen leaves the red blood corpuscles and goes through the capillary walls to the cells of the tissues. When the red blood corpuscles lose oxygen they turn dark in color. While the oxygen is passing out to the cells of the tissues, carbon dioxide and other waste matter leave the cells and pass through the capillary walls into the blood.

If the oxygen given off to the tissues is not all needed at once, it is stored up in the muscles and other tissues for future use.

What we mean by bad air.—When there is not enough oxygen in the body for its various organs they are unable to do their work properly, and the health is injured.

The mind cannot be clear and bright, nor can the muscles be strong and active, if we breathe air that contains too little oxygen and too much carbon dioxide.

Coal gas, from a stove or furnace, and the gas used for lighting are both poisonous. Air containing them is injurious to health. Damp cellars and old wells often contain poisonous gas.

A bad smell is nature's warning that our health may be in danger from something near us. Yet bad air does not always have a bad smell. Sewer gas and other poisonous gas may be entirely without odor.

How good air is made bad.—Every time you breathe you take oxygen from the air and add carbon dioxide to it. If you shut yourself up in a small room by closing the windows and the door, you will soon make the air bad by breathing. In crowded rooms there is too little oxygen and too much carbon dioxide unless there is proper ventilation.

Lights and fires in a room consume oxygen and give out carbon dioxide. Decaying animal or vegetable matter in or near a dwelling is sure to pollute the air. Drain pipes, when defective, may allow poisonous gas to escape into dwelling houses.

Coal stoves are sometimes sources of danger. If the dampers leading to the chimney are closed too soon after fresh fuel is added to the fire, a large amount of very poisonous gas may escape into the room.

Pools of stagnant water should not be allowed near dwellings. If such pools are used to receive refuse they are sure to contaminate the air.

Harmful effects of breathing bad air.—The harmful effects of breathing bad air are proved in a striking manner by the story of the Black Hole of Calcutta. One hundred forty-six English prisoners were confined for eight hours in a small room, eighteen feet square, with only two narrow windows to admit fresh air. Out of this number ninety-six died during the first six hours, and there was a total of one hundred twenty-three dead at the end of the eight hours. Only twenty-three of the entire one hundred forty-six managed, by keeping near the open windows, to secure enough fresh air to preserve life. Those at a short distance from the windows were obliged to breathe the same air over and over again until it contained so little oxygen and so much carbon dioxide that it could not sustain life. This story, of course, gives an account of an unusual event, but it serves to show the deadly effects of air that is deprived of oxygen and loaded with carbon dioxide.

Air rendered slightly impure by breathing is not dangerous to life, but it is injurious to health. A stay of only one or two hours in a tightly closed room, with no means of allowing fresh air to come in or foul air to get out, produces drowsiness, dullness, and headache. In a badly ventilated school-room, the pupils soon become dull and appear stupid, because the mind cannot be clear and active without fresh air.

In a room in which the air can be changed frequently by ventilation, each pupil does not need so many cubic feet of fresh air space as in a room in which the air cannot be frequently changed. The ventilation and air space of a class-room should

furnish at least three thousand cubic feet of fresh air every hour to each pupil. If a room is well ventilated, one who comes in from outdoors finds the air fresh and sweet. If he finds the air close and oppressive at ordinary temperatures, the room is not well ventilated.

Those that spend most of their time in badly ventilated rooms, into which the sun seldom or never shines, are pale and have a sickly appearance. In such persons the blood and tissues are starved for want of oxygen and poisoned by an excess of carbon dioxide, and the power to resist diseases of the lungs is greatly lessened.

Ways of ventilating.—In order to keep the air in a room fresh, it is necessary to provide some means by which fresh air may be brought in and foul air may be allowed to escape.

This is an easy matter in summer, for then windows and doors are open a large part of the time. But it is quite different in winter when all openings are tightly closed to keep cold air out; yet fresh air is just as necessary in winter as it is in summer.

Every properly constructed house or public building is so arranged that, in the winter, fresh air can be brought in, warmed, and then distributed to every part of the building.

In houses where no special means are provided for ventilation the supply of fresh air must come in through the windows and doors—chiefly through the windows. Care must be taken to avoid a draft, and especially a draft of cold air. But you can ventilate a room in several ways without making a draft. One

way is to raise the lower half of the window and place under it a frame, like the frame of a fly screen, that has flannel instead of wire fastened to it.

Another way is to raise the lower sash a few inches and fill the space under it with a board. Air will then pass in between the sashes, and will take an upward direction. Thus a direct current of air upon those in the room will be avoided. Any contrivance for ventilation will answer that will admit a sufficient amount of air without producing a draft.

The need of fresh air during the night is often overlooked. Sleeping apartments should be thoroughly ventilated during the day, and no one should sleep in a room in which there is not a window sufficiently open to admit plenty of fresh air.

Every one should spend at least a small part of each day in the open air. Even on cold or stormy days, if your health is good, wrap up well and spend some time out of doors. To every healthy person a brisk walk on a frosty morning is a tonic. It raises the spirits, increases the circulation of the blood, and produces a feeling of comfort and strength throughout the body.

Cleanliness.—Besides being properly ventilated, the houses in which people live should be clean. Dust that is allowed to collect on floors and walls and furniture is breathed into the lungs, and injures the health. School-rooms, especially, should be clean; and, in order that they may be kept clean, they should have hardwood floors that can easily be scrubbed, or floor coverings that will not catch and hold the dust. Any loose-meshed

floor covering, such as cocoa matting, is a collector of dust and disease germs.

Suffocation.—Owing to accidental causes of various kinds, breathing may, at times, become difficult, or may entirely cease. Very prompt action is sometimes required to prevent death from suffocation.

Smoke and fumes.—Whenever it becomes necessary to pass through sulphur fumes or smoke, a large wet handkerchief, a wet towel, or other wet cloth should be held over the mouth and nose, so as to prevent the fumes or smoke from passing into the lungs.

Coal gas.—A common cause of suffocation is breathing coal gas from a choked or defective coal stove, from the fumes of burning charcoal, or from a gas burner. In all such cases prompt removal into the fresh air is necessary.

Drowning.—In case of drowning, if the person taken from the water is still breathing, he should be carried, if possible, to the nearest house and put into a hot bath; or cloths wrung out of hot water may be applied to the chest and abdomen, and the body be briskly rubbed. Heat tends to increase the breathing and to stimulate the circulation. In all cases of suffocation, great care must be taken to remove at once all obstructions from the mouth and throat, so that fresh air can reach the lungs.

Artificial respiration.—The object of artificial respiration is to imitate as nearly as possible natural breathing. This method should be promptly applied in suffocation where breathing has ceased, or has become very feeble. Full direc-

tions for doing this are given under "What to do in a case of drowning," in the appendix on page 332. Efforts to restore persons from suffocation by drowning, or from any other cause, should be continued for a long time, even though no signs of life are apparent.

Effects of alcohol on the lungs.—The tissues of the body, when in health, possess, in large measure, the power of resisting disease. This power is greatly diminished in those who have formed the habit of drinking alcoholic liquor. This lessened power of resisting disease is very marked in lung tissue. Those who are in the habit of drinking alcoholic liquor are more liable to have pneumonia and consumption of the lungs, and are less likely to recover from these diseases than those who do not drink alcoholic liquor.

Effects of alcohol on growth.—The cells of a child's body are putting forth great effort in order to grow and increase in number. To do this the child requires a sufficient supply of oxygen, food, pure water, exercise, rest, and sunshine. Successful growth can take place only when the protoplasm of the cells is healthy and vigorous. Anything that lessens the activity of the protoplasm interferes with the proper growth and development of the body.

It is well known that alcohol, even when weakened very much by the addition of water, has a harmful effect upon the activity of protoplasm in the cells of both plants and animals. This harmful effect has been observed so often that alcohol is called a protoplasmic poison.

The protoplasm in cells of the tissues of growing children is easily injured. Alcoholic liquor in any form, and even in small amounts, is injurious to children and growing persons because it hinders growth and retards both physical and mental development.

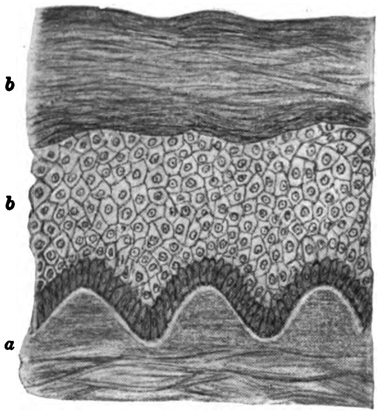
SUMMARY

1. The trachea divides into two branches, and the bronchial tubes divide until they end in small air sacs.
2. Tiny capillaries are fitted into the walls of the air sacs.
3. When we inhale, the chest becomes larger, the lungs expand, and air passes in.
4. When we exhale, the chest becomes smaller and its wall presses on the lungs. Air is then forced out.
5. We should breathe through the nose, and not through the mouth.
6. The larynx contains the vocal cords.
7. The opening between the vocal cords is called the glottis.
8. Vibrations of the vocal cords cause vibrations of air, and vibrations of air beat upon the ear and cause sounds.
9. As blood is flowing along the capillaries in the air sacs, oxygen goes from the air to the blood, and carbon dioxide goes from the blood to the air.
10. As the blood is flowing along the capillaries of the tissues, oxygen goes from the blood to the cells, and carbon dioxide goes from the cells to the blood.
11. Too little oxygen, or too much carbon dioxide, in the air we breathe impairs the health.
12. Living rooms should be ventilated at all times, and should be kept as free as possible from dust.
13. Every one should spend part of the day in the open air and sunshine.
14. Alcohol weakens the lungs, making them more liable to contract disease and less liable to recover from it.

CHAPTER XI

THE SKIN AND THE KIDNEYS

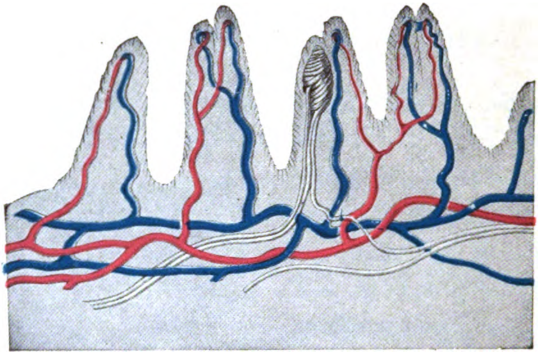
Our bodies are protected by a smooth, pliable covering which we call the skin. It consists of two parts. The outer part is called the epidermis, or scarf-skin; the inner part is called the dermis, or true skin.



a, TRUE SKIN; *b*, *b*, LAYERS OF SCARF-SKIN (Magnified)

The epidermis.— If you have ever examined a blister you have probably noticed that the skin is puffed out and that there is water below it. It is, however, only the epidermis that is puffed out. The dermis is below the water. The epidermis is made up of layers of cells placed one on another. The cells of the outermost layer are always wearing out and being shed from the surface in the form of flat, lifeless scales. The cells of the layer next to the dermis are always increasing in number by division and furnishing new cells to take the place of those that are shed.

The cells of the outer layers of the scarf-skin have no feeling, for these layers contain no nerves. If you prick these outer layers with the point of a needle you will feel no pain. More-



NERVES AND BLOOD TUBES IN TRUE SKIN
(Magnified)

over, you will see no blood, unless the point of the needle passes on into the true skin, for the scarf-skin contains no blood tubes.

If the scarf-skin is rubbed or pressed day after day it will become thicker. For this reason the skin on the palm of the hand and the sole of the foot often becomes quite thick and hard. This explains why boys that go barefoot in the summer can walk over rough, and even stony, ground without hurting their feet.

In the inner layers of the cells of the epidermis there are tiny granules of coloring matter. It is this coloring matter that causes differences of tint in individuals, and of color in

races. In the skin of white people there is very little coloring matter; in the skin of the negro there is a great deal.

The dermis.—The dermis lies below the epidermis. In the dermis there are both blood tubes and nerves. The surface of the dermis is not smooth and even, but rises up into the epidermis in small elevations called *papillæ*. These papillæ vary in shape and size in different parts of the body. In the palms of the hands and the soles of the feet they are arranged in rows, forming ridges and furrows that can be seen with the naked eye. The picture on page 141 shows how the cells of the epidermis fill in the spaces between the papillæ, and also form a smooth layer above their summits.

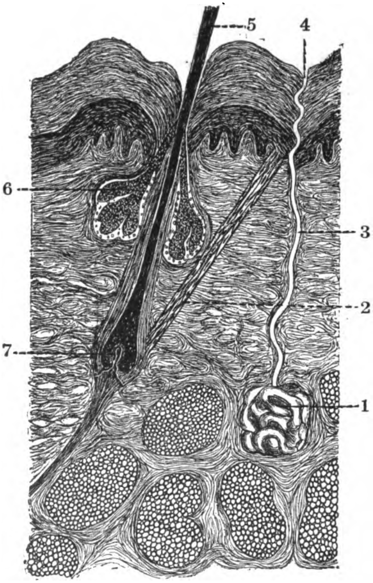
The papillæ contain capillaries and nerves. The nerves end in little knobs, and it is by means of these nerve endings that we feel everything that touches us. The dermis is very sensitive because of its many nerve endings, and if the epidermis is removed, the uncovered place will smart with pain. If you have a blister on your hand, it does not hurt until it breaks. The epidermis is then removed and the dermis is exposed.

There are so many blood tubes in the dermis that you cannot prick it with the point of a fine needle without puncturing one or more tubes and causing blood to flow. The small arteries coming from the interior of the body divide into networks of capillaries near the surface of the dermis. The capillaries are especially abundant in the papillæ. They lie in the dermis and extend up to, but not into, the epidermis.

Some papillæ are shown in the sketch on the opposite page.

Some of them contain capillary blood tubes, and one contains an ending of a nerve.

Nerves end in the skin in two principal ways. Some nerves end in the dermis in little swellings or knobs, mainly in the



SECTION OF SKIN

1. Sweat gland. 2. Muscle. 3. Duct. 4. Pore. 5. Hair. 6. Oil glands.
7. Papilla, showing capillaries

papillæ. Other nerves divide in the dermis just beneath the epidermis. From these nerves, fine delicate fibrils pass upward and end in the lower layers of the epidermis. Nerve endings are especially abundant in the tip of the tongue, the skin on the

palms and the tips of the fingers, the tip of the nose, and other parts specially sensitive to touch. This explains why the sense of touch is so acute in the finger-tips and other highly sensitive parts.

Perspiration.—On a warm day, water, or perspiration, as we call it, comes out of the skin and collects in drops on the face and other parts of the body. This is called sensible perspiration, because it can be observed. But whether the day is warm or cold, whether we are awake or asleep, we are perspiring all the time. Day and night, perspiration slowly rises from the surface without our knowledge. This is called insensible perspiration, because it cannot be observed.

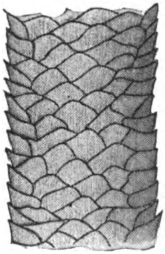
The perspiration we see is a colorless, salty liquid. It is chiefly water, and contains a small amount of common salt, and also a little of such waste matters as carbon dioxide and urea, which pass out of the body in this way.

The amount of perspiration from an adult in twenty-four hours is said to be about two pounds. But, of course, the quantity varies greatly with circumstances.

Sweat glands.—The skin of nearly all parts of the body contains very fine tubes, the inner ends of which are coiled into knots. After leaving the knots, the tubes twist into spirals and afterward open on the outer surface of the skin. The part of a tube that forms the knot is called a sweat gland; the rest of the tube is called a sweat duct; the opening on the surface is called a pore. The cells in the knots, or glands, take from the blood the material that makes the perspiration, which

then passes along the sweat ducts and comes out on the surface of the skin through the pores. It is estimated that there are more than two millions of these pores on the surface of the body.

Hair.—In the dermis are many little pockets or sacs, called hair *follicles*. Hairs grow out of these pockets. In the lower animals the hair is stiff and coarse; in human beings it is soft and fine. Here is a picture of a bit of human hair as it looks through a magnifying glass. You can see from it that the cells that form the hair overlap like fish scales.



BIT OF HAIR
(Magnified)

Hair does not look much like skin, yet it is made up wholly of changed cells of scarf-skin. They are pressed together lengthwise and grow only in length.

From the bottom of each hair follicle there runs a tiny muscle that ends in the outer part of the true skin. Find it in the picture on p. 144. When this little muscle contracts, it makes the hair stand more erect. When the hairs on a cat's back bristle at the sight of a dog, it is because the little muscles controlling the hairs have contracted and pulled the hairs erect.

The bottom of each little hair follicle is the top of a papilla, on which the root of the hair rests. The hair gets its nourishment from the network of capillaries in the papillæ. The growth of a hair takes place at the root only. Here the cells are constantly increasing in number by division. As a result, the older cells are pushed outward and the hair increases in length, but not in circumference.

Small granules of coloring matter give the hair its color. When the coloring matter disappears the hair becomes gray. In a hair are numerous little spaces into which air makes its way from the ends of the hair. The air in gray hairs gives them a silvery appearance.

Hair protects the head from the direct rays of the sun in hot weather, and prevents too rapid loss of heat in cold weather.

The skin of the top of the head is called the scalp. The cells of the outer layer of the scalp are shed from time to time, just as cells are shed from the surface of the skin in other parts of the body. These scalp cells become entangled in the hair, but are easily removed by brushing.

The hairs that grow on the edge of each eyelid are called eyelashes. The eyelashes catch particles of floating dust that might get into the eyes; and they also act as a screen from the bright sunlight, Thus, in two ways, they protect the eyes.

The oil glands.—In health, the hair is kept soft and glossy by means of oil. The oil is made by oil glands lying beside the root of the hair. It is then poured out upon the root of the hair and gradually finds its way to the surface of the skin. Each hair has one or more of these glands. Find the oil glands in the picture on page 144.

The nails.—The nails that protect the ends of the fingers and toes are developed from scarf-skin. They are cells of the epidermis in a different form. The edge of the nail, except at the free end, rests in a groove made by the skin. Growth takes

place at the root, and also from the bed, or matrix, on which the nail rests.

When the nails are kept clean and well trimmed they are beautiful ornaments. Biting the nails injures them. It is a habit that is frequently formed in youth and is sometimes quite difficult to give up. The best remedy is to keep the nails cut very short until the habit is overcome.

Uses of the skin.—You have already learned that one use of the skin is to protect the body, and that another is to provide for the escape of some waste matter through the perspiration. Still another very important use of the skin is to regulate the heat of the body. This heat, you remember, is produced by oxidation in the tissues. Oxidation takes place in the cells of all the tissues, but chiefly in the cells of the muscles and the glands. The heat is then distributed all through the body by means of the blood, and thus the temperature of the various parts is equalized. The heat of the skin, for example, depends upon the amount of blood flowing through it. When the arteries of the skin are dilated and contain much blood, the skin is warm; when they are contracted and contain less blood, the skin is cooler.

While heat is being constantly produced in the body, heat is also being lost from the body all the time. A part of this loss takes place in the act of breathing. The cool air breathed in becomes warmer in the lungs; and, when it is breathed out, heat is lost from the body. Furthermore, the air surrounding the body is usually cooler than the body. Consequently, heat is

lost from the skin in the same way that heat is lost from a piece of iron that is taken from a furnace and allowed to cool in the open air. When the body is in a state of health, the production and the loss of heat are so regulated that the temperature of the body remains the same.

When your body is becoming heated through running or other work, the arteries of the skin dilate and contain more blood. But the heat also stimulates the sweat glands to pour out abundant perspiration on the skin to cool the body. If you sprinkle water on a floor on a hot day, the air in the room becomes cooler afterward. The air becomes cooler because some of its heat is used to change the water into vapor, or evaporate it. The cooling of the body by perspiration is caused in the same way. Some of the body's heat is taken from it and used to change the perspiration into vapor.

On the other hand, when your body is surrounded by cold air, the muscles in the arteries of the skin contract, so that the arteries become smaller and hold less blood. More of the blood then remains in the interior of the body, and less comes to the skin, where heat would be lost rapidly. At the same time the sweat glands become less active, and little perspiration is evaporated from the skin.

The power of the body thus to regulate heat is so great that the temperature of the body is almost the same in summer and in winter. It scarcely varies, whether we live in arctic regions, where the temperature may be 50° F. below zero or lower, or in the tropics, where it may exceed 115° F. The

temperature of the body, under ordinary circumstances, is 98.6° F.

In our bodies, the greatest loss of heat occurs through the skin. It is estimated that the loss through the skin is nearly 77 per cent. of the entire loss of heat from the body; that the loss through the lungs is a little more than 20 per cent. of the entire loss; and that nearly 3 per cent. is lost in other ways. These figures show how important the work of the skin is in regulating the heat of the human body.

On the other hand, the dog, which perspires but little, loses a much larger amount of heat from the lungs. The panting of the dog when he is overheated is his way of cooling off. He breathes in a large amount of air, which becomes heated and takes heat from the body as it is breathed out. He also puts out his tongue, and loses some heat by the evaporation of moisture from its surface.

Mammals and birds are called warm-blooded animals. In each kind of these animals the temperature of the healthy body remains the same whether the surrounding air is cold or warm. The normal temperature of the human body, as we have learned, is 98.6° F.; the temperature of the dog is 102° F.; and the temperature of the swallow is 111° F. As a rule, the more active an animal is, the higher is its usual temperature. These active animals consume a large amount of food, and produce a large amount of heat. They lose, however, a sufficient amount of heat to keep the temperature of the body uniform.

The temperature of invertebrates, so far as is known, and of

such vertebrates as reptiles, frogs, and fishes, varies with the temperature of the surrounding air, soil, or water. Such animals are called cold-blooded animals. The temperature of their bodies is usually only a very little above the temperature of what surrounds them. Many of these animals are sluggish, and consume only a small amount of food. Consequently they produce only a small amount of heat.

Bears, woodchucks, and some other warm-blooded animals, pass the winter in a torpid state, and are said to hibernate. The temperature of the body becomes nearly as low as that of the surrounding soil in which they burrow; breathing almost ceases; and the heart beats very feebly. In this condition very little food is needed, and that is obtained from the fat of the body. In the fall these animals are fat, but in the spring they are lean. A mammal, such as the woodchuck, which lives on green vegetables, could not survive a northern winter if it did not hibernate, and thus avoid the necessity for a continuous supply of its accustomed food.

When an animal, such as a rabbit, is entirely covered with a thick varnish, it dies in a short time. It was formerly thought that this happens because poisonous matter which should be discharged through the skin is shut up in the rabbit's body. It has now been proved beyond a doubt that death in these cases is caused by a rapid loss of heat, and not from poisoning by waste matter, for varnished animals wrapped in cotton wool remain well and suffer no bad effects.

It has been shown also by experiment that the whole surface

of the human body can remain, for eight or ten days, covered with a layer that allows nothing to get through it, and yet suffer no injury. There is on record a story of a small child that was gilded to represent an angel. In a few hours the child died, but death was due in all probability to some poison in the material used for gilding.

Bathing.—The skin cannot be healthy and do its work well unless it is clean. A small amount of waste matter is left on the surface of the skin after the water in the perspiration has evaporated. This becomes mixed with oily matter from the oil glands, and with scales from the outer layer of the epidermis. These soon form a coating that tends to irritate the skin and gives rise to unpleasant odors.

Those accustomed to take a daily morning bath think it very little trouble and are uncomfortable without it. It requires only a few minutes and the labor is trifling. Every one in ordinary health should take a daily bath. Water, soap, a sponge, a basin, and a towel are all that are needed for a sponge bath.

Should the water be warm or cold?—No rule can be given that is suitable for every one. Warm water softens the oily scales on the surface of the epidermis, and, used with soap, is an important aid to cleanliness. Warm water also causes the arteries of the skin to relax and become larger, so that a large amount of blood comes to the surface. A warm bath gives rise to a pleasant, comfortable feeling; but if the bath is prolonged, a feeling of depression and weakness follows. Warm baths,

like heat of any kind, weaken the muscles in the arteries of the skin and lessen their power to contract. As these arteries thus remain too large, they contain too much blood, and heat is lost rapidly from the body if one is exposed to cold. For this reason, a person who goes into cold air after taking a warm bath is liable to take cold.

A warm bath at bedtime is soothing. If the muscles are sore and ache after a day of hard labor or other severe exertion, nothing is more soothing than a warm bath. It causes the arteries of the skin to dilate; and, since much of the blood is withdrawn from the muscles, the aching and soreness vanish speedily. Those who suffer from difficulty in getting to sleep will find that a warm bath at bedtime often invites refreshing slumber.

A warm foot-bath containing mustard is useful in cases of convulsions in children. A tablespoonful of mustard should be put into a quart of warm water, and the feet should be placed in it while the child is lying on the bed. The mustard bath should be continued until the skin of the feet and ankles is well reddened.

A cold bath causes the muscles in the walls of the arteries of the skin to contract. These arteries then become smaller and force part of the blood away from the skin to the interior of the body. For this reason we feel chilly and shiver when we first get into cold water. In a few minutes the arteries of the skin relax, blood returns to the skin, and gives rise to an agreeable feeling of warmth and comfort. The bath should be ended

before this feeling passes away, and should be followed by a brisk rubbing of the skin. A cold bath acts as a tonic and produces increased vigor of both body and mind. Cold baths tend to stimulate circulation and to increase the oxidation of food in the tissues of the body. Increased appetite and increased excretion of waste follow.

In most cases it is best to use cold water for bathing. When warm water is used for the first part of a bath, it may be changed for colder water during the latter part. A bath is said to be cold if the temperature of the water does not exceed 65° or 70° F. Very cold baths should be used only by those that are in robust health.

Some persons complain of catching cold after taking a bath, especially in cold weather. This is because they fail to dry the skin properly. Two towels should always be used after a bath: the first one to wipe off the water, and the second one to rub the skin until it is thoroughly dry and warm. If the skin remains moist, the evaporation that follows chills the surface of the body and tends to produce a cold.

Persons that take cold easily should bathe the shoulders, chest, neck, and face with cold water every morning. The skin should then be rubbed briskly until it is thoroughly dried.

Bathing the head.—The scalp and hair should be washed thoroughly with soap and water at least every two weeks. When this is not done, scales and dust collect and interfere with the health of the hair and the scalp.

Water that is quite warm should be used first to soften the

oily scales, and then cold water should be used. Great care should be taken to dry the hair thoroughly after washing it, for the danger of taking cold after bathing the head will thus be avoided, even in cold weather.

Swimming.—Swimming is healthful exercise, but many persons stay in the water too long at one time. Twenty minutes or half an hour is quite long enough. No one should go into deep water when he is very tired, or when he is warm and is perspiring freely, for at such times he is more liable than usual to be seized with cramps.

Colds.—Colds are most frequent during spring and fall. At such times there are frequent changes of temperature, the air is often cool and damp, and winds are common.

Colds are not due merely to exposure to very cold air or frost, else they would be more common in mid-winter and in Arctic regions. The more usual causes of taking cold are sitting or standing in a draft, going from a warm room to a cold one, want of proper protection for the feet, sitting or standing still after vigorous exercise while the surface of the body is moist from perspiration. The last is a frequent cause, for we often take cold after being too warm.

Another very common way of taking cold is by "catching" it from some one else who has a cold. Colds are contagious. They are often brought home by children that have "caught" them by close contact with other children at school. If a cold gets into a family it is liable to infect the whole household before it stops. The infection is probably carried solely by the

breath. Care should be taken to avoid conveying the infection from one person to another. Any person with a cold should, as far as possible, remain apart from the rest of the family and from friends.

Some persons are more liable than others to take cold, and this liability is due generally to a faulty manner of living. Those that get very little fresh air because they stay in-doors unless the weather is fine; those that live in over-heated houses and sleep in rooms with windows carefully closed for fear that they may take cold; and those that overburden themselves with clothing, so that they cannot take active exercise without perspiring freely, are liable to take cold from the slightest exposure.

An ordinary cold should not be allowed to take its own course without treatment. Certain diseases, such as smallpox, protect the body against a second attack. But one attack of a common cold, especially if it is neglected, renders the body more liable to another attack. The common household remedy of a hot drink and a hot foot-bath at bedtime is useful in arresting or weakening the force of a cold, especially if used at the beginning of an attack.

Prevention of colds.—The well-known causes that produce colds, should be avoided. Just enough clothing should be worn to keep the body warm. If too little is worn the skin may be chilled, and we may take cold. If too much is worn, slight exertion causes perspiration, the body is kept over-heated and becomes sensitive, and so we are liable to take cold on the

slightest exposure. The common mistake of putting too much clothing on one part of the body and too little on another part should be avoided. It is unwise to try to prevent a cold in the chest by putting on too many wraps, or by wearing chest protectors. Too much muffling leads to perspiration, renders the chest and the throat more sensitive, and increases the liability to take cold. The feet should be protected against cold and dampness.

A part of every day should be spent out of doors. Those that are accustomed to be out of doors in all kinds of weather seldom take cold.

Sleeping rooms should be well ventilated. Both day and night a window should be sufficiently open to insure thorough ventilation.

Great care should be taken to avoid sitting or standing still when the skin is moist from perspiration, unless extra wraps are worn while the body is cooling.

Our climate is changeable. In a few hours we are frequently subjected to marked differences in heat and cold. It is impossible to change our clothing every time the weather changes. The only way to protect ourselves in such a climate is to keep the body in perfect health, so that we may be exposed to rapid changes in temperature without any danger of taking cold.

The daily cold bath is of great value in protecting the body against colds, for it strengthens the muscles in the arteries of the skin. Exercise of any muscle causes it to become stronger. Cold baths exercise the muscles in the arteries of the skin, and

give them greater power to contract. Accordingly, when the body is exposed to a sudden change in temperature, the muscles in the arteries of the skin contract promptly, the arteries become smaller, less blood comes to the surface of the body, and the liability to take cold from exposure is lessened.

Clothing.—Articles of clothing are usually made from wool, silk, cotton, and linen. Clothing does not furnish heat to the body. It only retains heat that is made in the body, and so keeps it warm.

Clothing that is loosely woven retains heat better than clothing that is closely woven. Loosely woven clothing contains a considerable amount of air in the little spaces between its fibres, and heat does not pass readily through dry air.

Again, clothing that absorbs the moisture of perspiration into the substance of the fibres retains heat better than clothing that does not absorb moisture into the substance of its fibres. You remember that heat is lost from the air of a room on a hot day when water that is sprinkled on the floor evaporates. In a similar manner, heat is lost from the surface of the body when moisture evaporates from clothing we wear. If the clothing that is next to the body absorbs moisture into its fibres, that moisture evaporates slowly, and heat is lost from the body slowly. But, if clothing holds moisture largely in the spaces between its fibres, and absorbs but little into the substance of the fibres, then the moisture evaporates rapidly, heat is lost rapidly from the body, and we feel chilly.

Wool, in both of these particulars, is an excellent article of

clothing. Woollen garments retain heat well in cold weather because they are loosely woven, and hold a considerable amount of air in their meshes. Wool is better also than any other article of clothing for absorbing moisture into the substance of its fibres, and allowing it to evaporate slowly. Those that are subject to rheumatism, or that take cold easily, should wear woollen garments next to the skin throughout the year. The weight of the garment should vary with the season.

Silk comes next to wool in its power to absorb moisture into its fibres. It is therefore an excellent material for undergarments, especially for those persons that cannot wear wool next to the skin. The chief obstacle to the general use of silk for clothing is its cost.

Linen is closely woven, its meshes are small, and contain little air. Linen does not absorb moisture into its fibres so readily as wool or silk, but holds the moisture more in the spaces between its fibres. Consequently, linen garments allow heat to escape from the body more rapidly than silk or wool. Garments made from linen are more suitable for hot than for cold or changeable climates.

Cotton, too, is closely woven, and does not absorb moisture into its fibres so well as wool or silk. It allows heat to escape from the body freely. Cotton, therefore, makes cool garments for warm climates or seasons. It is cheap and wears well. For these reasons it is very generally used for clothing. Cotton and linen garments should not be worn next to the skin by those that take cold easily or that are subject to rheumatism,

because these materials allow too rapid evaporation and cooling of the body.

Waste matter and excretion.—The work of removing waste matter from the body is called excretion, and the organs that do this are called excretory organs.

The excretory organs.—The chief excretory organs are the lungs, the skin, and the kidneys. You learned that by means of the lungs we get rid of carbon dioxide and also of a small amount of water in the form of vapor. They are contained in the air that we breathe out, and are produced in the body by the oxidation of carbohydrate food.

The tissues of the body are built up from proteid food, which always contains nitrogen; and the waste matter that results from the breaking down of the tissues also contains nitrogen. This waste matter resembles ammonia, and is called urea. If this waste matter is allowed to accumulate in the blood and in the tissues it acts as a poison. It must be carried out of the body.

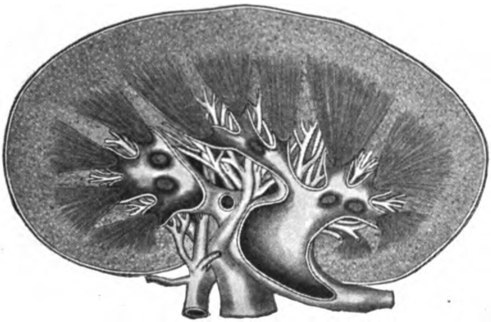
Through the skin we lose, in the form of perspiration, a very small amount of carbon dioxide, a trace of urea, and a considerable amount of water.

The kidneys are the organs that remove from the blood nearly all of the urea that is excreted from the body.

The kidneys.—There are two kidneys, one on each side of the spine. Their upper ends lie behind the lower ribs.

The kidneys are well supplied with blood. In the picture on page 162 you can see that one kidney lies on each side of the aorta. A branch of the aorta, called a renal artery, enters

each kidney. As the stream of blood flows downward through the aorta, a part of it is diverted from the main channel and flows into the renal arteries. After circulating in the kidney this blood passes out by the renal veins. It flows from the renal veins into the vena cava inferior, which returns the blood from the lower part of the body to the heart. The kidneys take

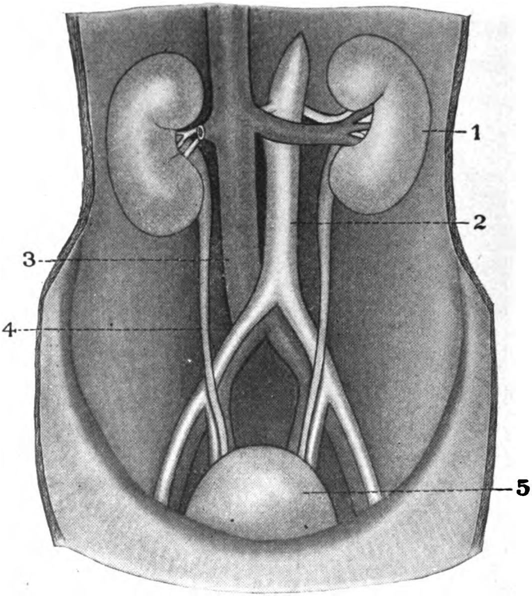


SECTION OF A KIDNEY

urea and water from the blood as it goes through them. This fluid, which is called urine, passes by means of ducts, named ureters, to the bladder, where it is stored until it is expelled from the body. Only a small part of the blood in the aorta passes through the kidneys each time it circulates. The kidneys do not remove all the urea from the blood, but, by constantly removing part, they keep this waste matter from accumulating to an amount that would be harmful to the body.

This picture shows the appearance of the cut surface of a kidney after it has been divided. The kidney substance, which

appears in the picture to be striped and marked with many fine lines, is composed of a mass of tiny blood tubes and of other tiny tubes that carry water. This water has been taken by the



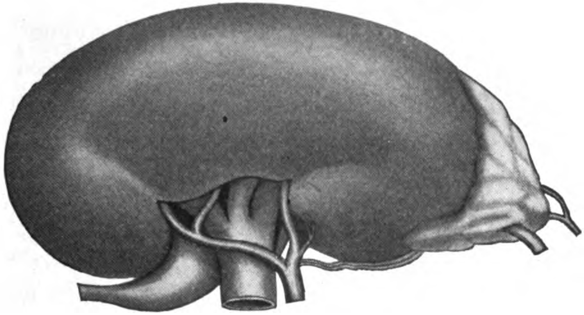
KIDNEYS IN THEIR POSITION

1. Kidney. 2. Aorta. 3. Inferior vena cava. 4. Uretur. 5. Bladder

kidneys from the blood, and contains in solution the urea that must be removed from the body.

Effects of alcohol on the skin.—Alcohol evaporates rapidly when applied to the skin, and gives rise to a sensation of coolness. It also hardens the outer layers of cells in the epidermis.

When taken internally, alcohol affects the skin chiefly by its action on the nerves which end in the small arteries of the dermis. These nerves end in muscles that are wrapped in a circular manner around the blood tubes and form part of their walls. Nerves ending in these muscles control them, and when the circular muscles in the wall of an artery contract, the size



A KIDNEY

of the artery is decreased, and it contains a smaller amount of blood. When the circular muscles relax, the artery dilates and contains a greater amount of blood. Alcohol lessens the control of the nerves over the muscles in the walls of the arteries. The muscles relax, and the arteries then contain more blood.

After even a moderate drink of alcoholic liquor the skin of the face becomes flushed and warm, because the little blood tubes of the skin are dilated and contain more blood than usual. If these tubes are kept dilated by continued drinking they may in

time become permanently dilated and give the face a permanent reddish color.

Effect of alcohol on the temperature of the body.—As the blood tubes of the skin dilate under the influence of alcohol, a larger amount of blood than usual comes near the surface of the body and, in cold weather, is cooled by the surrounding air. The action of the sweat glands is increased at the same time and the temperature is reduced by increased evaporation from the skin. In this way the heat of the body is lost more rapidly than it would be if no alcohol were taken.

The extra amount of blood contained in the dilated blood tubes makes the skin feel warmer because it warms the endings of the nerves in the skin. It is this feeling of warmth that deceives those that drink alcoholic liquors, and gives rise to the false notion that alcohol makes the body warmer on a cold day. The fact is that the body is losing heat faster than it should. If a large amount of alcohol is taken the loss of heat may be very great.

Effects of alcohol on the kidneys.—The effects of alcohol on the kidneys resemble closely its effects on the liver. As a result of the irritant action of alcohol on the kidney cells they may swell, and, if the irritation is continued, their protoplasm may change more or less completely to fat. The connective tissue cells also of the kidneys may be affected by the continued irritation of alcohol. These cells may increase in number, press upon the other kidney cells, and injure or even destroy them. These changes interfere very seriously with the import-

ant work of the kidneys in removing from the blood urea, which would act as a poison if it were to accumulate in the blood.

The following letters and statement are submitted to show that it is safer in both cold and hot climates not to drink alcoholic liquors.

NEW YORK, *June* 7, 1907.

Dear Sir:—According to the reports of Dr. Nansen and the Duke of the Abruzzi, both of whom reached high latitudes on the polar ice, no alcoholic stimulants were used on their sledge trips.

In our two years' stay in the Arctic, our sledge parties made nearly four thousand miles across ice and snow under the peculiarly trying conditions of the polar regions. We never carried any alcoholic stimulants as part of our sledge rations, believing them to be detrimental.

Smoking was allowed and indulged in by a large number of the men. They usually lit their pipes when they had crawled into their frozen sleeping bags after the day's hard work of hauling and lifting the heavy sledges and driving the capricious dogs was over.

From observation on many sledge journeys, I have come to the belief that the use of tobacco is harmful also, and that men addicted to its use cannot endure so much hardship as those who are not.

Yours truly, ANTHONY FIALA,
Commanding Ziegler Polar Expedition of 1903–1905.

NEW YORK, *June* 18, 1907.

Dear Sir:—In reply to your recent letter, I would say that during the summer months, in interior Labrador, we experienced a great variety of temperature, ranging sometimes from nearly ninety degrees at midday to below the freezing point at night and, as fall approached, well down to zero. Protracted storms of rain and

sleet and snow were frequent; and often, for days and nights together, myself and men were compelled to work and sleep in water-soaked garments. Each man carried a pack of considerably over a hundred pounds, and the physical strain was tremendous, while for a good part of the time our rations were scant.

During my winter journey of two thousand miles with dogs and snowshoes, it was not unusual to have, even at midday, a temperature of fifty degrees below zero. Often we slept in snow *igloos* or on the open snow fields with no fire with which to warm ourselves.

Had I used, or permitted my men to use, alcoholic liquors as a beverage, I am confident my expedition would have been a failure. My observation is that a man taking even one small drink of liquor in the morning is incapacitated for his day's work under the conditions that we faced. I may go even further, and say that one to be fit should abstain absolutely from the use of alcohol for weeks or even months before entering upon such an expedition.

Yours very truly, DILLON WALLACE.

In a large American Medical work, *Twentieth Century Practice of Medicine*, Dr. Wolfred Nelson says, under "Yellow Fever," in Vol. XX, page 448: "The moderate drinker, as a rule, is lost from the start. The liver in such cases plays a most important rôle. The use of alcohol in any form by newcomers within the tropics is a very pernicious habit. The climate alone taxes the liver, and alcohol adds to the trouble. If one must live in the tropics, or try to live there, let total abstinence be made a rule of life."

SUMMARY

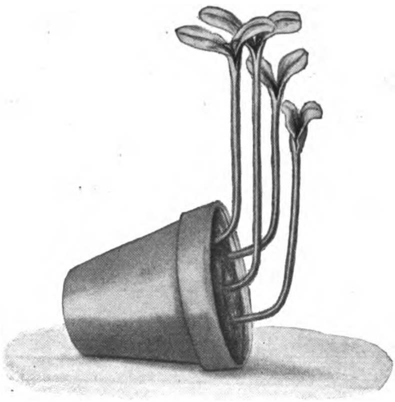
1. The skin consists of two parts: epidermis and dermis.
2. The outer cells of the epidermis continually fall off, and the cells of the lowest layer divide to form new cells.
3. Papillæ in the dermis contain endings of nerves, by which we feel.
4. Nerve endings are most numerous in the finger-tips and other parts that are most sensitive to touch.
5. The dermis is supplied with a large number of blood tubes.
6. Perspiration is secreted in the sweat glands.
7. Hair is made up of changed cells of the epidermis.
8. A hair rests on a papilla at the bottom of a follicle.
9. Oil glands beside the roots of the hair furnish oil which keeps the hair soft and glossy.
10. The nails are formed from changed cells of the epidermis.
11. The skin protects the body, allows waste matter to escape in perspiration, and regulates the heat of the body.
12. A warm bath should be taken at night.
13. A cold bath should be taken in the morning.
14. A cold bath acts as a tonic for those who can take it. It improves the health and protects against "catching cold."
15. Wool is the best article of clothing in cold weather.
16. Alcohol lessens the control of the nerves over the muscles in the walls of the arteries in the dermis.
17. Owing to the increased amount of blood in the skin, the drinking of alcohol lowers the temperature of the body on a cold day.
18. Alcohol injures the kidney cells and the connective tissue that holds them together.

PART III—THE FUNCTION OF MOVEMENT

CHAPTER XII

PLANT AND ANIMAL MOVEMENTS

The power to move.—Only living things have the power to move. Things without life stay in the same place and position until made to move by some outside force. A ball when struck with a bat will fly through the air, but it must be struck before it will move.

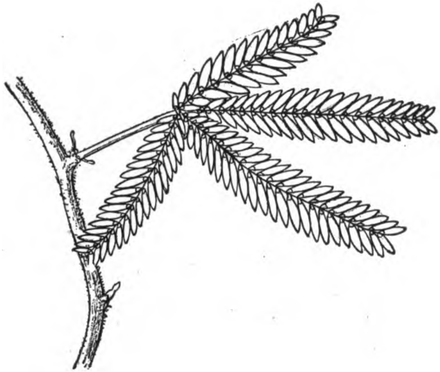


STEMS GROWING UPWARD

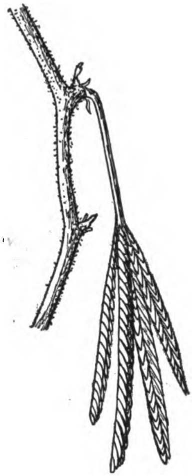
But living things have in themselves the power to move. They all have the power to move a part of the body, as a leaf, a hand, or a foot. Animals and a few plants have the power also to move from place to place.

Some movements of plants.—Plants can move different parts, as a root, a leaf, or a stem. On a sunny morning, the leaves and growing top of a sunflower turn toward the east to face the sun, and follow it throughout the day, facing toward tne west in the evening. The stem of a young plant grows

away from the centre of the earth and the root grows toward it. If a flower pot that contains a growing plant a few inches in height is placed on its side, the end of the stem will turn



LEAF OF SENSITIVE PLANT BEFORE IT IS TOUCHED



LEAF OF A SENSITIVE PLANT AFTER IT IS TOUCHED

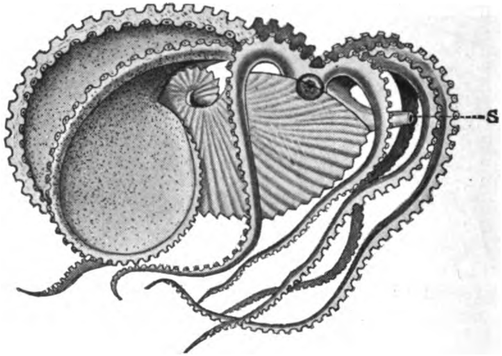
slowly and grow upward, and the end of the root will turn and grow downward.

The sensitive plant shows a remarkable example of plant movement. It has little leaves arranged in pairs on four separate stems. If one of the leaflets is touched, all the leaflets of that leaf will quickly fold together in pairs, and the leaf-stalk will turn downward and remain in a drooping position for some time.

Certain movements of some plants are called sleep movements, because they usually take place in the evening and in the morning. In the evening the leaves of the clover fold them-

selves together. In the morning these leaves take again an open position. Other familiar sleep movements are the closing at night and the opening in the morning of such flowers as the tulip, crocus, dandelion, and water-lily.

Locomotion.—The power of living things to move from place to place is called locomotion. The animals that you



A PAPER NAUTILUS
(*s*) Siphon

know best move about freely from place to place; they must do so in order to find their food. Yet there are animals, such as oysters, that can move about for only a short time. Very soon they settle on some shell or rock, and then have no power to move away from it; they do not have to move about to find their food, but get it in one spot. There are, moreover, tiny plants that move from place to place in liquids. Some of these are the disease germs, called bacteria, which move about in milk, water, or blood, though they are so small that they can

be seen only with a microscope. Many of these little plants move by means of little hair-like fibrils, called cilia, that project from their surfaces.

Swimming.—One simple form of animal locomotion is the sort of swimming that is seen in the movements of such animals as the cuttle-fish and the nautilus. They fill a cavity in the front part of the body with water, and then quickly expel this water through a funnel, which is usually called a siphon. As this stream of water is forced against the surrounding water, the animal is propelled rapidly in the opposite direction, that is, backward.

The lobster swims backward by striking the water with his tail as he bends it downward and then forward under his body.

The feet and limbs of many animals are especially suited to swimming. Ducks, geese, swans, frogs, otters, muskrats, and beavers have some, or all, of their feet webbed, and use them as paddles with which to push against the water.

Of all organs of locomotion the best adapted to swimming are the tails and the fins of fishes. A fish bends its tail to the right side of the body and strikes back against the water in straightening the tail. Then it bends the tail to the left side and strikes back. This powerful push against the water, as the fish forces its tail back straight after bending it to one side, sends the fish rapidly along. The force with which the salmon strikes the water with its tail is so great that it can swim at the rate of twenty-four feet a second, and can leap out of the water over cascades twelve or thirteen feet high.

Columbia River salmon leave the Pacific Ocean in the spring, and swim up the Columbia and its tributaries in order to spawn,

MAP SHOWING FLIGHT OF AMERICAN GOLDEN PLOVER SO FAR AS DETERMINED
From the Year Book of the Department of Agriculture for 1903

sometimes more than a thousand miles; for they are found that far away from the sea in Salmon River, as it winds among the Sawtooth Mountains of Idaho.

Flying.—As fishes swim by pushing against the water with fins and tails, so birds and insects fly by pushing against the air with wings. The stroke of the wing against the air keeps the body up and also sends it forward. The swiftest flyers among insects are bees, wasps, and dragon-flies; among birds, the swiftest are pigeons, swallows, wild ducks, hawks, and falcons. A homing pigeon has been known to make a flight of seven hundred miles in thirteen and a half hours. Some birds cover in their yearly travels as much as sixteen thousand miles. The common night hawk flies as far north in spring as Alaska, where it makes its nest and rears its young. As winter comes on it flies as far south as Patagonia. The American golden plover nests on the shores of the Arctic, and on islands in that ocean, and winters in southern Argentina.

Crawling.—Another form of locomotion is crawling. In swimming, the animal pushes against the water; in flying, the animal pushes against the air; in crawling, the animal pushes against the earth, or whatever other surface it may be crawling on.

The earthworm crawls by means of very small bristles. These bristles can be pushed out from the body and fixed in the ground like little pins. The worm can then push ahead its forward part, or draw up its hinder part.

Snakes crawl by means of shields on the under surface of their body, the edges farther from the head being movable. The snake moves these edges out from its body, grips the surface over which it is moving, and pushes itself along.

Walking and running.—Walking and running are brought about by a backward push against the surface that the feet are treading on. If you look at a footprint in moist sand you will see that the pressure is made just before the toes are raised, for the footprint is broken at the toe.

Organs of movement.—From this study of movement you have learned that different animals have organs of different shapes with which to move from place to place. The fin, the wing, and the foot are suited to the water, the air, and the earth. Nature adapts the size and shape of an organ to the work it has to do. In the higher animals these organs of movement are of different shapes and sizes, but they are made up of the same kinds of material.

Muscles.—In animals made up of different kinds of tissue each kind has its special work. In such animals the tissue that has for its special work the producing of movement is muscle tissue. This tissue in an animal does not consist of one mass, but of different bundles, each of which is called a muscle. Each of these muscles has to do only with movements of its own part of the body; one muscle, or set of muscles, moves a foot; another muscle, or set of muscles, moves the hand, and so on.

Bones.—The muscles that produce most of the familiar movements of animal bodies are fastened at their ends, to solid parts. The muscles pull on these solid parts and produce movements. In animals that have a spinal column these solid parts are called bones. They lie within the body, and the principal muscles lie

on them. In insects, such as flies and bees, in crabs, lobsters, and many other animals, the hard part of the body is on the outside, and the muscles that produce movement are fastened to this hard part and lie within it.

The controlling organ in movement.—In order that muscles in the same body may work together harmoniously and each do just the amount of work that is required, they need some controlling organ. In animals that move by means of muscles, there are nerves that control these muscles and regulate their movements.

SUMMARY

1. Only living things have the power to move.
2. Plants move their leaves, stems, and roots.
3. The stem of a young plant grows away from the centre of the earth and the root grows toward it.
4. The leaves and leaf-stalks of a sensitive plant move quickly if it is touched.
5. Some movements of the leaves of plants are called "sleep movements."
6. Most animals and some plants have the power of locomotion.
7. The nautilus and some other animals move backward by forcing a stream of water against the surrounding water.
8. The lobster swims backward with its tail.
9. Many animals have webbed feet for use as paddles in swimming.
10. A fish swims by pushing against the water with its tail and fins.
11. Salmon sometimes swim up rivers a thousand miles or more to spawn.
12. Birds and insects fly by pushing against the air with their wings.
13. In crawling, walking, or running, an animal pushes against the earth, or whatever it is moving over.

14. It is the function of muscle tissue to produce movement.

15. Many muscles are attached to solid parts, and pull on them to produce movement.

16. In some animals the solid parts are inside the body, in others the solid parts are on the outside of the body.

17. The movements of muscles are controlled by nerves.

CHAPTER XIII

THE BONES

Bones as organs of movement.—Though there is no power of movement in bone as there is in muscle, a great many of the movements of the body are caused by the pulling of one bone toward another, or away from another, by the muscles that are fastened to the bones. Muscles pull the bones this way or that, according to the needs of the animal.

Bones as the framework of the body.—Perhaps you have seen the framework of a large building, or, perhaps, you may have been in a shipyard, and have seen the framework of a big ship that was being built. The framework of a building or a ship gives shape to it and also supports its other parts.

Inside the bodies of the higher animals there is a strong framework, which supports and protects the soft tissues and gives to each animal its peculiar shape. This framework is called the skeleton, and consists of bones closely joined and neatly fitted together.

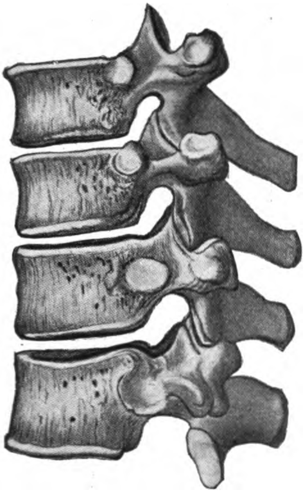
In the body of a man the skeleton is made up of two hundred bones of many shapes and sizes. There are little irregularly shaped bones, as in the wrists; short, slender bones, as in the fingers and toes; long bones, as in the arms and legs; rings of bone, as in the spinal column; curved plates of bone, as in the

THE FRAMEWORK, OR SKELETON, OF THE BODY

skull; and flat, broad bones, as in the shoulder blades. The picture on the opposite page shows how all these different bones are arranged to form the framework of the body.

THE SPINAL COLUMN

The spinal column.—The central structure in this framework is the backbone, or spinal column. It is a strong column in the middle of the back, and to it, either directly or indirectly, the other parts of the skeleton are attached. It supports the skull at its upper end, and the arms at a distance from it; the ribs are fastened to it at the sides; and it rests on the hip bones, which are supported by the legs.

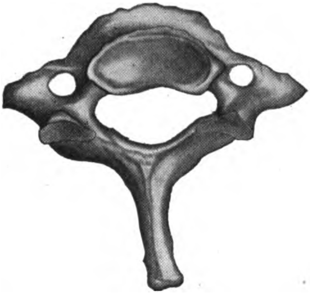


FOUR VERTEBRÆ

The spinal column of a grown person consists of twenty-six bones, called *vertebræ*, placed one over the other like spools on a string. The vertebræ are separated from one another by a thin cushion of cartilage, which is elastic and allows the bones to move on one another so that the spinal column may be

bent to some extent in different directions. These cushions also prevent injury to the bones of the spine, and to other parts of the body, from sudden jars, such as occur in jumping or falling.

The vertebræ in different parts of the spine vary in size and shape, and are given different names. At the top there are seven belonging to the neck and called the *cervical*, or neck, vertebræ. Then come twelve vertebræ to which the ribs are attached, and these are called *dorsal*, or back, vertebræ. Next come five vertebræ which are called *lumbar*, or loin, vertebræ. Below the lumbar bones are the *sacrum*, or sacred bone, and the *coccyx*, so named because it is supposed to resemble a cuckoo's beak.

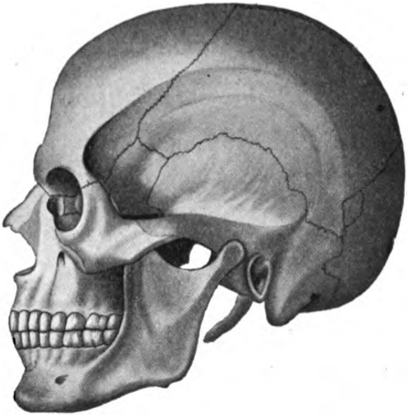


A VERTEBRA OF THE NECK

This picture of a *vertebra* shows a large hole in the centre through which a delicate cord passes down from the brain. It is called the spinal cord. The small holes in the sides of the vertebra are for blood tubes. In the picture of four vertebræ on page 179 you can see how the vertebræ are joined together, and you can see also the spaces for cushions of cartilage between the vertebræ.

The skull.—Eight plates of bone form the *cranium*, which is a case enclosing the brain. These eight bones are united by irregular, saw-like edges that lock firmly together. The joint made by these edges is called a *suture*.

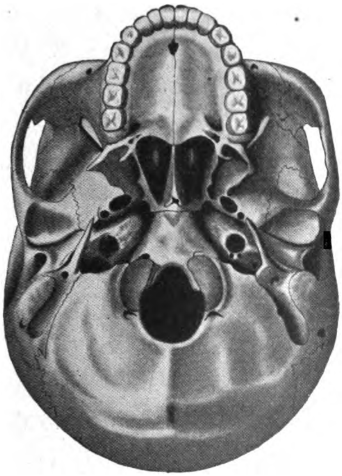
Fourteen bones of different shapes form the face. Two deep depressions, one on each side of the nose, form sockets for the eyeballs. The nose is only partly made of bone. Its end is composed of cartilage.



A VIEW OF THE SIDE OF THE SKULL

The bones of the cranium and of the face together form the skull, which rests on the spinal column.

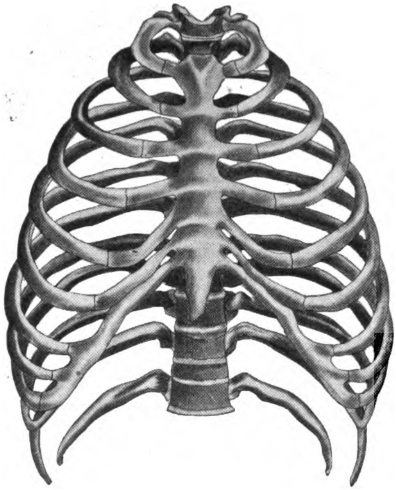
The picture below shows a view of the base of the skull. The large hole is for the spinal cord as it extends downward from the brain into the cavity of the spinal column.



A VIEW OF THE BASE OF THE SKULL

The ribs and the sternum.—There are twelve ribs on each side. They are all fastened to the spine by means of joints. The first seven are called the true ribs, and are joined in front to the breast-bone, which is also called the sternum. The other five are called false ribs. The

first three of these are fastened in front by cartilage to the rib above. The front ends of the remaining two are free, and these are called floating ribs. The joints allow a slight movement of the ribs in breathing.



THE RIBS AND BREAST BONE

The ribs, spine, and sternum form a cage of bones for the protection of the heart and lungs. This part of the body is called the chest, or *thorax*.

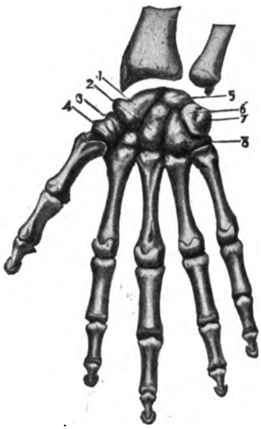
The clavicles and the scapulas.—A clavicle, or collar-bone, can easily be felt on each side of the upper part of the front of the chest. It extends from the sternum to the shoulder and forms a brace that keeps the shoulder back.

A scapula, or shoulder-blade, can be felt on each side at the upper part of the back. Each scapula is a strong, irregularly shaped bone, and is connected by joints with the long bone of the upper arm and with the clavicle of the same side.

The arms and the hands.—In the upper arm there is a long bone called the *humerus*. It extends from the shoulder to the elbow. In the forearm there are two bones of nearly equal size, the *radius* and the *ulna*, which extend from the elbow

to the wrist. (See the picture on page 178.)

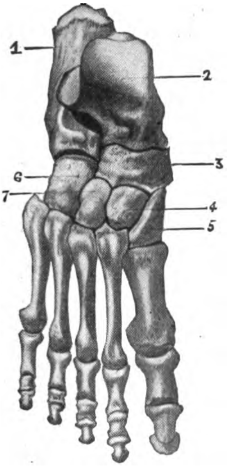
There are eight short bones, called the *carpal* bones, in the wrist, and five long bones, called the *metacarpal* bones, in the palm of the hand. As you can see by the picture, there are fourteen bones in the fingers. They are called *phalanges.*



BONES OF THE WRIST AND HAND

The legs and the feet.—The longest and largest bone in the body is the thigh-bone, called the *femur.* The knee-joint is protected by a small bone, the knee-pan, or *patella.* There is no bone at the elbow that corresponds to this bone at the knee.

There are two bones in the leg between the knee and the ankle. One, the *tibia,* is large and strong; the other, the *fibula,* is small and slender.

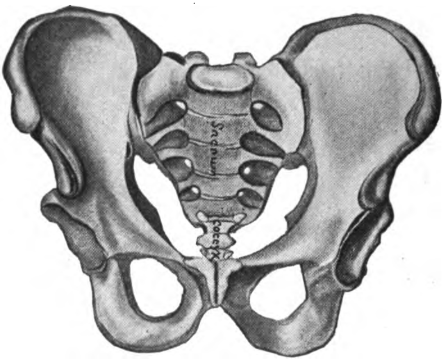


BONES OF ANKLE AND FEET

There are seven short

bones, called *tarsal* bones, in the ankle and instep. The five long bones of the foot resemble the five long bones in the palm of the hand, and the fourteen bones of the toes are much like the fourteen bones of the fingers.

The big toe, however, differs from the thumb. The bones of the big toe lie beside the bones of the other toes and parallel



THE PELVIS

with them. The bones of the thumb are not parallel with the bones of the fingers, but are so arranged as to allow the thumb to be brought opposite the fingers. This arrangement adds greatly to the usefulness of the hand by increasing its power to grasp and hold things.

The pelvis.—Two irregularly shaped heavy bones form the hip bones. Together with the sacrum they make the pelvis, a bony basin that supports the abdomen.

Color of bone.—A bone in a living animal is pinkish-white

in color. This color is due to the presence of blood in the tiny blood tubes of the bone. After a bone has been cooked, or exposed for a time to the weather, its blood disappears, and the bone loses its reddish color and becomes white.

A CHICKEN'S LEG-BONE TIED INTO A KNOT

Composition of bone.—Bone is composed of animal matter and mineral matter closely blended. The mineral part of a small bone may be removed by soaking it for three or four days in a pint of water to which two ounces of muriatic acid have been added. When the bone is taken out, only the animal part is left. This animal part is so soft and flexible that if the bone is a long one, such as the leg of a chicken, it may easily be tied into a knot.

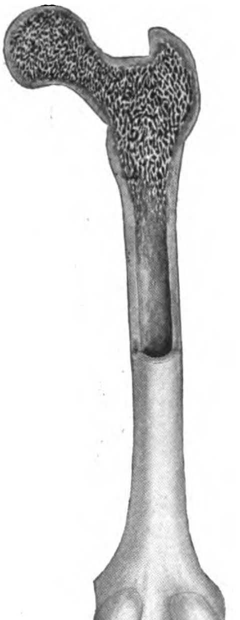
On the other hand, the animal part of a bone may be removed by fire. If a bone is placed in a hot fire for two or three hours the animal matter may be entirely consumed and only the mineral matter will remain.

The animal matter of bone resembles cartilage. It makes the bones tough and elastic; it forms about one-third of the bone in grown people. The mineral matter makes the bones hard and strong. It forms about two-thirds of the bone in grown people.

Structure of bone.—The outer part of all bones is smooth and hard. It is composed of dense, compact tissue. The inner

part of all bones, except the shaft of a long one, is made up of tissue that is loose and spongy.

If a long bone that has been well dried is divided lengthwise, as is shown in the picture, it is seen that the ends are not hollow but composed of spongy tissue covered with a thin layer of dense, compact tissue. The shaft forms a hollow cylinder, the walls of which are composed of dense, compact tissue.

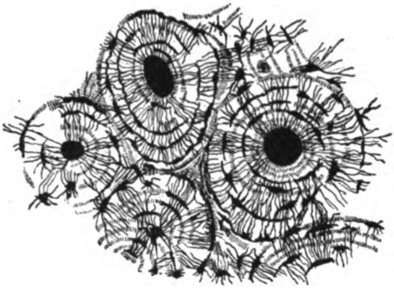


A LONG BONE

The hollow cylindrical shape of these long bones gives them both strength and lightness. The advantage of this shape for strength may be shown in this way: Take two similar sheets of paper. Roll one into a hollow cylinder and fold the other so that the folds will lie upon one another. Now support these pieces of paper at their ends, and suspend a weight from the middle of each. You will find that the cylindrical paper will sustain a much heavier weight than the paper that is folded.

On examination with a microscope the compact parts of bone are seen to resemble the spongy parts in structure. But in the compact parts the solid matter is packed more closely together and the spaces between its particles are much smaller.

This picture shows the appearance of bone when highly magnified. The large spots represent channels in the bone for blood tubes. These channels are called the *Haversian* canals. The smaller dark spots arranged around them in circles represent cavities in which the bone cells are contained. These cavities communicate with each other by means of minute canals, which are shown as fine dark lines running out from the spaces in all directions. Part of the blood oozes through the walls of the blood tubes, flows out from the Haversian canals and feeds the bone cells. In early life the bone cells take from the blood mineral matter which they deposit around themselves as intercellular material. It is largely composed of lime and makes the bones hard and firm.



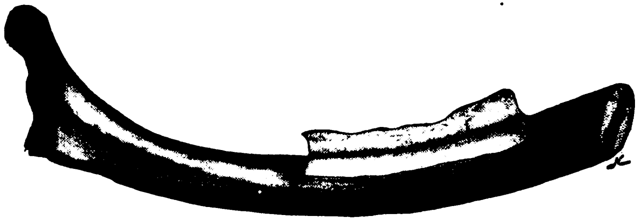
BONE HIGHLY MAGNIFIED, SHOWING STRUCTURE

Marrow.—The central canal in the shaft of long bones contains a yellow, pulpy substance called marrow. It consists chiefly of fat and blood tubes. In the spaces of spongy bone there is also a kind of marrow, which is reddish in color.

Periosteum.—Closely adhering to the surface of all bones is a thin sheet or membrane, called the periosteum. It is composed of connective tissue, arteries, and veins. From these arteries in the periosteum branches pass through small holes

into the interior of the bone. Here they divide into smaller branches, which extend along the Haversian canals in the bones. The small holes for these arteries can easily be seen by examining the surface of a dry bone.

The long bones increase in length by successive deposits of bony material added to their ends. Increase in thickness is



THE PERIOSTEUM

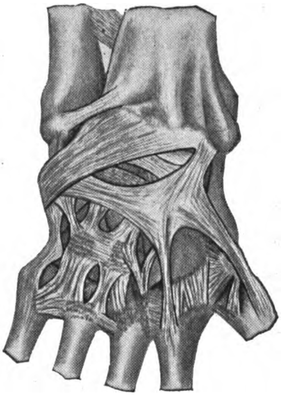
caused by deposits beneath the periosteum, like successive rings formed under the bark of a growing tree.

The joints.—The bones of the skeleton are fastened together by means of joints. Some joints, like those of the hip and the shoulder, allow very great freedom of movement. Others, like those of the spine, allow slight movements, while at the joints of the skull the bones are fixed and cannot move.

You know that doors work on hinges. The knee and elbow are both good examples of hinge joints. The upper end of the humerus and the upper end of the femur are round, like a ball. The ball of the humerus fits into a cup-shaped depression, or socket, in the scapula at the shoulder, and the ball of the femur fits into a socket in the hip-bone. The joints at the hip and shoulder are therefore called ball-and-socket joints.

The ends of the bones in the more movable joints are covered with cartilage in order to keep them from rubbing against one another as they move.

Disease of the joints is most prevalent in childhood and early life. A common form of joint disease is caused by tuberculosis. It occurs frequently at the hip, and is known as hip-joint disease. The best means for preventing such diseases include an abundant supply of wholesome food, avoidance of alcohol or tobacco, daily exercise in the open air, and sanitary dwellings, into which the sunshine is allowed to enter freely.



LIGAMENTS OF WRIST AND HAND

The ligaments.—Bones are held together at the joints by short, tough, white, glistening bands of connective tissue, called ligaments. These are soft and flexible and allow great freedom of movement, yet are strong and tough and hold the bones securely in their proper places. In the picture you can see how the bones of the wrist are firmly held together by ligaments.

The inner surfaces of the ligaments of movable joints are lined with a smooth membrane that secretes an oily fluid, called *synovia,* from its resemblance to the white of egg. Synovia is sometimes called joint-oil, as it prevents friction in the joint of the body in much the same way that oil prevents friction in the joints of a machine.

Sprains.—Two of the most common injuries to joints are sprains and dislocations. A sprain is caused by the forcible stretching and twisting of a joint. This injury occurs most frequently in the wrist and ankle. A sprain of the wrist usually results from a fall on the hand, and a sprain of the ankle is usually caused by a misstep or a fall upon the foot. The injury may be very slight, and recovery may take place in a day or two; or the injury may be very severe, and recovery may be slow and tedious. A bad sprain is often worse than a fracture of the bone; not because the injury is really more severe, but because sprains are so often neglected. In slight sprains the pain may be quickly relieved by cold applications. All severe sprains should be treated by a doctor.

Dislocations.—The ends of bones that form a joint are sometimes displaced. When the joint surfaces are entirely separated from each other the dislocation is said to be complete. When the joint surfaces are still partially in contact, though displaced from their usual positions, the dislocation is incomplete. The ligaments that hold the bones in place are stretched and torn. As soon as possible the aid of a physician should be obtained, and the bones should be put back into their usual positions. Bones are sometimes dislocated and broken at the same time. The swelling, bruising, and pain that are often present may make it difficult, or impossible, to determine at once whether the bones are also fractured or not. In such cases the X-rays are very helpful. If the dislocation is simple, and the bones are put back with little delay, the injury

is usually soon repaired, although the joint may be somewhat stiff and weak for a while.

Broken bones.—A bone may be broken as the result of a fall or other accident. Pain is usually felt at the point where the break occurs, and some swelling of the parts usually appears within a few hours. When a bone is broken, the periosteum, blood tubes, and nerves at the place where the fracture has occurred are injured. Blood trickles out between the fragments under the flesh and the skin. This blood is absorbed in a short time and takes no part in the healing process.

When the bone is set and the healing begins, the cells of the periosteum and marrow divide and thus increase in number, forming a soft mass around and between the broken ends. Lime salts are then deposited by the cells, and the soft mass gradually becomes hard and firm. The broken ends are in time securely united by the formation of new bone around and between the broken fragments. This new bone that unites the fragments is called the *callus*. It usually forms a hard swelling and may be felt at the site of the fracture for a long time after union is complete.

In young people a broken bone will unite in two or three weeks, but in grown persons the time required may be from four to six weeks, or even longer. Even after firm union of the broken ends has taken place, the parts remain weak for a time.

Care of the bones.—The bones of young persons are liable to grow out of shape if pressure is applied to them too constantly. Improper positions in standing, walking, or sitting, if

continued, may lead to deformity. Constant stooping or bending to one side may in time cause one to be round-shouldered, flat-chested, or may give rise to curvature of the spine. Any habitual one-sided position, if persisted in, may give rise to a deformity which may become permanent.

Bone deformities seldom occur in strong, vigorous, well-fed, ambitious children, but are most frequent in those that are pale and delicate and have weak muscles.

Such deformities are rare, too, in persons that are compelled to maintain an erect position. Soldiers, and those that are accustomed to carry weights, such as baskets of fruit or buckets of water, on their heads do not develop deformities, simply because they are obliged to hold the body erect. Many deformities are due to want of life enough to sit up or stand up straight. They are consequently most frequent in careless, lifeless persons, who are in the habit of sitting much of the time with their backs twisted, or bent to one side in a half-curved position.

How to prevent deformity.—Good food, regular meals, sufficient sleep, healthful surroundings, and suitable exercise in the open air are of the greatest importance. They tend to harden the bones, develop the muscles, and give the strength that is necessary to maintain the body in a proper posture.

Children should form the habit of holding the body erect. While standing, the weight of the body should be firmly supported by both feet. In walking, the chest should be kept up and the head erect. It is true that by sitting or standing too long in one position certain muscles become tired, and that

to relieve them frequent change of position is necessary; but care should be taken to avoid stooping, or bending habitually to one side.

All clothing should be loose and comfortable. Shoes should not be too narrow, or have heels that are too high, for the bones of the feet may be forced out of place by such shoes. If the clothing about the waist is too tight the ribs may be pressed inward, and the organs in the thorax and in the abdomen may be pushed out of place and hindered in their work.

It is a false notion that tightly fitting garments give support and additional strength. They may appear to do so for a time, but it is a law of nature that constant artificial support to any part hinders development and is a cause of weakness. The chest and waist should never be constricted by clothing.

SUMMARY

1. Bones form the framework or skeleton of the body. The skeleton supports the soft tissues, protects them, and gives shape to the body.
2. The spinal column is the central structure of the skeleton.
3. This column has a hollow space for the spinal cord.
4. The spinal cord extends downward from the brain, through a hole in the base of the skull, into the spinal column.
5. The bones of the cranium are joined by irregular edges called sutures.
6. The ribs, spine, and sternum protect the heart and lungs.
7. The bones of the arm and hand resemble those of the leg and foot.
8. The pelvis rests upon the legs and supports the trunk.
9. Bone is made up of animal matter and mineral matter.
10. The outer part of bone is hard and compact. The inner part of short bones is spongy.
11. The shape of long bones makes them light and strong.

12. The Haversian canals in bones are channels for blood tubes.

13. Minute cavities containing bone cells are arranged around the Haversian canals. These cavities are connected by very small canals.

14. A thin membrane, called the periosteum, adheres to the surface of all bones.

15. The joints at the shoulder and hip are ball-and-socket joints.

16. The joints at the elbow and knee are hinge joints.

17. Bones are held together at the joints by ligaments.

18. The inner surface of a ligament of a movable joint is lined with a membrane that secretes an oily fluid.

19. A broken bone may be set, *i.e.*, the ends put together in their right position.

20. Bones may be bent out of shape by tight clothing or improper positions.

CHAPTER XIV

THE MUSCLES

How muscles produce movement.—Muscles have the power to contract, which makes them shorter; and to relax, which makes them longer. It is this power of contracting and relaxing that enables muscles to produce movement. They not only move themselves, but they cause bones to which they are fastened to move. The biceps, a muscle of the arm, is attached at its lower end to a bone of the forearm. When this muscle contracts it pulls on the bone of the forearm and the hand and forearm are drawn upward. In a similar way other muscles are fastened to the sides and back of the arm. When these contract they move the arm in other directions.

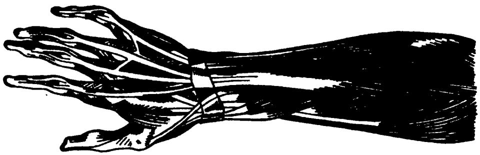
When the muscles on the right side of the neck contract the head is turned to the right, and when those on the left side contract the head is turned to the left (see page 197).

As we chew our food, muscles attached to the lower jaw contract and draw it downward, others contract and draw it up again.

Muscles of the legs, by contracting and relaxing, enable us to walk, run, and jump.

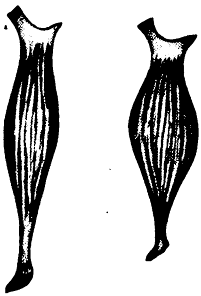
The tendons.—The tendons are white, glistening cords that connect muscle to bone or other part of the body. Some tendons are round, others are flattened.

In this picture the tendons of the muscles of the forearm are shown, and also their attachment to the bones of the fingers. When we move the fingers rapidly we can see the tendons that belong to the muscles of the back of the arm moving under the skin.

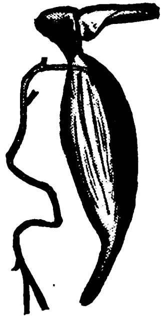


MUSCLES OF FOREARM AND THEIR TENDONS

How our muscles are made to move.—We have below on the left the picture of a muscle such as can be found in the leg of a frog. If this were a properly prepared muscle, about two inches long, instead of a picture, and we were to pinch it or prick it with a pin, it would shorten and become an inch and three-quarters, or perhaps only an inch and a half in length. It would then resemble the muscle on the right. Whenever we pinch or prick a muscle in this way, we are said to stimulate it. The stimulation makes the muscle contract and become shorter. We can stimulate a muscle and make it contract without touching it. A little nerve ends in each muscle. See the outline of a

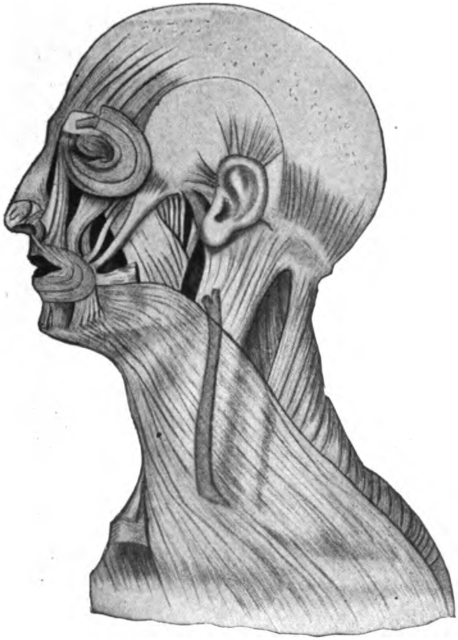


LEG MUSCLE OF A FROG



LEG MUSCLE OF A FROG WITH ITS NERVE

muscle with its nerve on page 196. If such a nerve is pinched or pricked the muscle will contract, although the muscle itself is not touched at all. When we pinch or



MUSCLES OF NECK AND HEAD

prick the nerve, we stimulate it, and thus start a message, or *nerve impulse* as it is called, that travels along the nerve and stimulates the muscle. When the nerve impulse reaches the muscle, the muscle contracts. Contraction of muscle in the

living body is caused in a similar way. Whenever you decide to close your hand, muscles lying along the front of the arm contract and draw the fingers down. When you determine to open the hand again, muscles lying along the back of the arm contract and pull the fingers up. A simple act of the will starts a nerve impulse that travels from the brain along a nerve, or nerves, to the proper muscles. On the arrival of this nerve impulse at the muscles, a contraction quickly follows. After a muscle has contracted, it returns sooner or later to its original length and shape, that is, it relaxes.

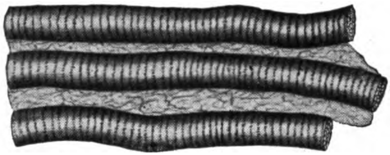
UNCONTRACTED BICEPS OF UPPER ARM

When a muscle contracts and relaxes several times in rapid succession it becomes fatigued. Its power to contract is diminished, or may be entirely lost. This power is regained, however, after a period of rest.

Voluntary muscles.—The muscles that are attached to the bones of the skeleton are often called *skeletal* muscles. They are the muscles by which we move a part of the body or move from place to place. For the most part they are arranged in pairs; for instance, one muscle, the biceps, pulls the arm up; its mate, the triceps, pulls the arm down. As one of the pair shortens, the other lengthens.

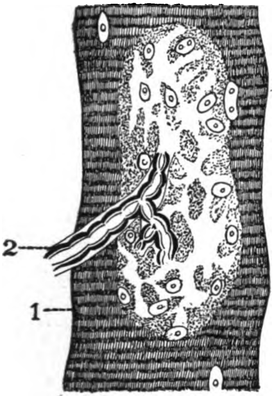
We can cause the skeletal muscles to contract whenever we wish; they are under the control of the will. For this reason they are also called voluntary muscles.

There are some voluntary muscles, as, for instance, the one around the mouth, that are not skeletal, since they are not fastened to any bone.



THREE FIBRES OF VOLUNTARY MUSCLE
(Magnified)

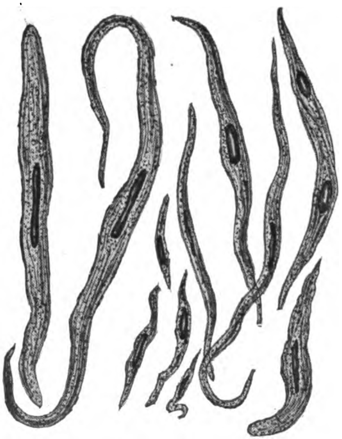
Structure of voluntary muscle.—A voluntary muscle is made up of a large number of small cells, called fibres, bound together into bundles by connective tissue and minute blood tubes. It is from the blood in these tubes that the muscles obtain the nourishment that makes them grow and gives them the power to contract.



VOLUNTARY MUSCLE FIBRE WITH NERVE ENDING
(Highly magnified)
1. Muscle fibre.
2. Ending of nerve.
From "Gray's Anatomy"

This is a highly magnified picture of part of a voluntary muscle fibre, with the end of a nerve attached to it. You can see fine lines or stripes that cross the fibre from side to side. On account of these, voluntary muscle is sometimes called striped muscle. When lean meat is boiled, the connective tissue is softened so that the bundles of muscle fibres fall apart or may be easily separated.

Involuntary muscle.—Many internal organs, such as the stomach, the intestine, the arteries, and the veins, contain muscles in their walls. These muscles contract at the proper time, whether we wish them to do so or not. They are not under the control of the will. For this reason they are called involuntary muscles. When the involuntary muscles in the walls of the stomach and intestine contract, the food in these organs is moved along and is mixed with the digestive juices. When the involuntary muscles in the blood tubes contract, they assist in pushing the blood along in its course through the body.



CELLS OF INVOLUNTARY MUSCLE
(Magnified)

Structure of involuntary muscle.—Involuntary muscle consists of cells cemented together along their edges so as to form sheets and bands. This picture shows cells of involuntary muscle separated from each other and magnified. You can see that these cells are not striped like voluntary muscles; hence involuntary muscles are sometimes called unstriped muscles. These muscles are also richly supplied with blood tubes.

The heart consists of a large mass of connected muscles. Heart muscle differs from other muscle. Its fibres are striped

like those of voluntary muscle, but the heart beats whether we wish it to do so or not. Its action is not under the control of the will. In this respect heart muscle resembles involuntary muscle.

Shape of muscles.—Muscles have many different shapes. Some are small, thin, and round; others are short and broad; while others are spread out like a fan. The shape of each muscle is adapted to the work that it has to do.

Uses of muscles.—One of the most important uses of muscles is, of course, to produce movement.

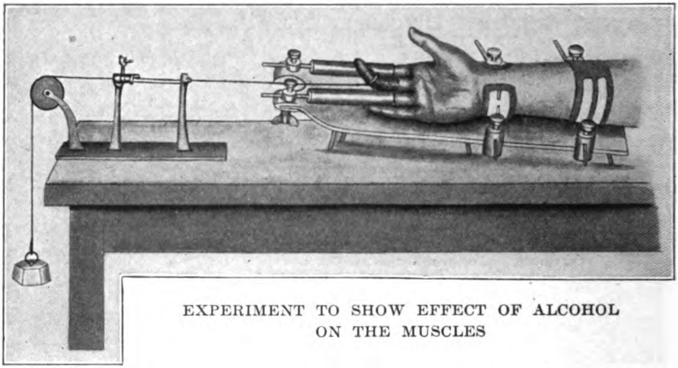
Another important use of muscles is to help produce bodily heat. On a cold day we swing our arms, and walk about or run, in order to warm ourselves. If we play or work hard on a warm day we become so warm that we perspire freely. The increased activity of the muscles causes more food to be oxidized in the muscle cells, and this increase of oxidation makes more heat in the body. It has been shown by actual experiment with a thermometer that blood is warmer after it leaves a contracting muscle than it was before it entered the muscle.

Still another use of the voluntary muscles is to cover the bones and, together with fat, give to the body its rounded form and graceful outline. They help also to enclose such cavities as the mouth and abdomen and protect the large arteries and nerves that lie beneath them.

Effects of alcohol on muscle.—Some people have the mistaken idea that by drinking alcoholic liquor they are able to do

an increased amount of work. But it has been proved by many careful experiments that such is not the case.

This is a picture of an instrument that is often used in making such experiments. A string fastened to the second finger



EXPERIMENT TO SHOW EFFECT OF ALCOHOL ON THE MUSCLES

is passed over a pulley and attached to a weight. The first and third fingers are placed in tubes to keep them from interfering with the second finger. In this experiment the muscles of the second finger are contracted and relaxed every few seconds, the weight being raised and lowered each time. This is continued until the finger is completely exhausted, and a record is kept of the number of times the weight was lifted.

In order to ascertain the influence of alcohol the experiment is tried on the same person at different times; at some of these times he drinks a small amount of alcoholic liquor, at other times he does not drink any. It has been found, as a result of these experiments, that alcohol at first gives increased power to

work for a short time. But very soon the power to work is greatly diminished, so that the total amount of work done with alcohol is less than that done without it.

These results are confirmed by the experience of army officers, employers of labor, athletes, and explorers; for they find that the body is in better condition for prolonged severe work when alcohol is not taken. In this connection, Count von Haeseler, Commander of the Sixteenth Army Corps in Germany, says: "The soldier who abstains altogether is the best man. He can accomplish more, can march better, and is a better soldier than the man who drinks even moderately. Mentally and physically he is better. Brandy is the worst poison. Next to it comes beer. For a soldier, water, coffee, and, above all, tea, are the best drinks."

Sir John Ross, commander of an expedition to the Arctic, says: "The most irresistible proof of the value of abstinence was when we abandoned our ship and were obliged to leave behind us all our wines and spirits. It was remarkable to observe how much stronger and more able men were to do their work when they had nothing but water to drink."

Surgeon-Major Reid, of the Coldstream Guards of the British army, says, in his report on the Suakim campaign in Africa: "No spirituous liquors have been used during this campaign. I am of the opinion that their absence has largely contributed to the efficiency of the troops during the arduous duties performed by them."

Those who drink beer and wine often become fat. The

alcohol is more readily oxidized in the cells of the tissues than the fat contained in the food. As part, at least, of this fat is not needed, it is stored up in different parts of the body. Some is stored in the connective tissue between the muscle fibres and interferes with the work of the muscles.

The following statement is quoted from an article on athletes in the *New York Herald* of March 14, 1909, by Mr. Michael C. Murphy, Coach of the track team of the University of Pennsylvania, and of the American Olympic team of 1908.

"Before concluding this article I want to sound just two more warnings to young athletes. If you want to become champions and emulate the examples of the men about whom I have been writing, then make sure that you leave alcohol and cigarettes alone absolutely. Especially beware of alcoholic stimulants while training. The men about whom I have written made their world records because they let these things alone, because in the main they were temperate and lived clean lives. They depended entirely on their good condition for their success.

"One of the strongest arguments I know of against alcohol, cigarettes, etc., for athletes is that the professionals, who train solely for the money they can make out of athletics, invariably leave them alone. They know they must win to make a living and that they cannot win when they disregard these important rules of training.

"Every drop of drink that an athlete takes means just so much more hard work to get into condition. I would also caution young athletes to avoid overloading the stomach and to keep scrupulously clean at all times. The man who breaks records is the man

who is temperate in all things. He is the man who has reserve speed and strength at the end of the contest, which always win for him and establish the new records."

Ann Arbor, Mich., *January* 8, 1909.

Dear Sir:—Your letter of the 4th inst. is received. I am very glad to inform you that young men under my care, training for the different branches of athletics, are required to abstain from the use of alcoholic liquors and tobacco. There is no question in my mind that the use of alcoholic liquors and tobacco interferes greatly with the development and physical condition of young men. The best athletes I have had under my care have been young men who have never used alcoholic liquors or tobacco in any form.

Very truly yours,

Keene Fitzpatrick,

Director, Waterman Gymnasium, University of Michigan.

Chicago, Ill., *July* 1, 1907.

Dear Sir:—It is my firm opinion, based on twenty-two years of participation in intercollegiate athletics, either as player or as coach, that the best results in physical development are secured only by total abstinence from the use of alcoholic liquors, tobacco, and other stimulants. My opinion is based on careful observation of the athletic work of youths who did and who did not use stimulants.

Sincerely,

A. A. Stagg,

Director, The Bartlett Gymnasium, The University of Chicago.

Philadelphia, Pa., *January* 11, 1909.

Dear Sir:—In reply to your letter of January 4th, I would say that all candidates for the foot-ball team abstain from the use of

alcoholic liquors and tobacco during the season. This is a cast-iron rule, which we never allow to be broken.

Yours very truly,

WILLIAM W. ROPER,

Foot-ball Coach, Princeton University.

SUMMARY

1. Muscles have the power to contract and relax. This power enables them to produce movement.
2. Many muscles are connected to bone by tendons.
3. Whatever causes a muscle to contract is said to stimulate it.
4. Nerves end in muscles, and the usual stimulus is a nerve impulse.
5. Voluntary muscles are under the control of the will.
6. They are generally arranged in pairs, one of which becomes longer as the other becomes shorter.
7. Involuntary muscles are not under the control of the will.
8. Heart muscle differs from other muscle. In appearance its fibres look like voluntary muscle, but their action is involuntary.
9. A large amount of body heat is produced in the muscles.
10. Muscles help to give the body its shape, to enclose cavities, and to protect arteries and nerves.
11. The use of alcoholic liquor and tobacco weakens the muscles.

CHAPTER XV

PHYSICAL EXERCISE

All organs of the body need exercise.—The natural and reasonable use of an organ, such as the arm, does not wear it out, but causes the arm to grow in size and increase in strength. The right arm, as a rule, measures from a quarter to a half inch more around than the left. This difference is entirely due tc the fact that the muscles of the right arm are used more than the muscles of the left. When muscles are used they increase in size and strength, but when they are not used they decrease in size and become weak.

As with the arm, so with all the other organs. The work that they do does not wear them out, but gives them increased power and health.

How exercise affects the muscles.—The function of muscle is to contract and relax. As a muscle contracts, the small arteries in it dilate and hold more blood, both at the moment of contraction and for some time afterward. A larger amount of food and oxygen comes to the cells of the muscles in the larger supply of blood. The effect of contraction is to stimulate the cells to take in this food more freely and thus build themselves up. In this way both the size and the number of muscle cells are increased by exercise.

How exercise affects the lungs, heart, skin, and nerves.—The effect of exercise is not confined to the muscles them-

selves, but extends to all other parts of the body. The muscle cells when exercised consume so much of the oxygen and food in the body that a greater supply of these substances is needed. Breathing becomes deeper and faster in the effort to supply an increased amount of oxygen, and the lungs and the muscles that are concerned in respiration are benefited by the increased activity. The greater demand for food gives rise to a feeling of hunger, so that as a result of regular exercise a man gradually eats more food, just as he breathes more air.

The increased demand for blood by the muscle cells affects the circulation, and the heart is stimulated to greater activity. Then as a result of the increased activity its muscle fibres are developed, and it becomes stronger.

The union of an increased amount of food and oxygen in the cells increases the amount of heat produced by oxidation. Because of the surplus of heat the skin becomes more active. The small arteries in the skin dilate, sweat glands work with greater vigor, and surplus heat is taken from the body as the perspiration is evaporated.

When muscles are exercised, the brain and nerves that control the movements of the muscles become active. A large number of the cells of the surface of the brain have the special work of sending out impulses to muscles to make them contract. In addition to these, cells in other parts of the brain become active in other ways. As a result, therefore, of muscular exercise the brain and nerves, too, are developed while performing their own functions, and so become better able to perform them.

Fatigue.—If one or more groups of your muscles are kept contracted for some time, or are made to contract often, you will feel fatigued. This feeling is due partly to the using up of the supply of food and oxygen contained in the muscle cells, and partly also to the presence in the cells of waste products, which are formed faster than they can be carried away. But fatigue is due more largely to the exhaustion of the cells of the brain which control the movements of the muscles. This is particularly true of those movements that require close attention and an effort of the will.

Amount of exercise.—It is impossible to make any rule for the amount of exercise that should be taken, because what is best for one person may be too much or too little for another. Exercise within proper limits is usually followed by more or less fatigue; but if there is not, after a night's rest, a complete recovery from the fatigue, it is safe to conclude that the exercise was too severe.

Time of exercise.—The best results are obtained when exercise is taken each day and at regular hours. The best time for exercise is before rather than after meals, but there should be an interval of at least half an hour for rest between the exercise and the meal. If exercise is taken too soon after a meal, so much blood may go to the muscles that there may not be enough in the digestive organs to enable them to secrete a sufficient amount of digestive juices.

In the case of those that are not robust, it is better to divide up the daily amount of exercise into two or three parts.

Kinds of exercise.—Any kind of exercise does all that is needed to benefit the different organs of the body if it causes the principal groups of large muscles to contract freely, without over-fatigue. It may be in the form of out-door games, in the form of practice in a gymnasium, or in the form of labor. In general, work or games in the open air are better than work or exercise in-doors.

The greatest benefits are obtained from exercises that cause contractions of the large muscles of the thighs, back, abdomen, and shoulders. Contractions of the smaller muscles, such as those of the hands and arms, are necessary for their own improvement, but do not furnish sufficient exercise to improve the condition of the different organs of the body. On the other hand, when exercise is taken that causes contractions of the large groups of muscles, breathing becomes deeper, and all the air cells of the lungs are called into action; circulation is quickened; digestion and excretion are stimulated; and the brain and nerves become more active in the performance of their functions.

If a moderate amount of such exercise is taken every day it improves the condition of the different organs of the body. They, therefore, become better able to do their work, and the body is brought into a state of health. For a body is healthy when all its organs are doing their work well.

Work.—Manual labor in the open air, if not too severe or prolonged, is one of the best forms of exercise. The farmer, the bricklayer, and others that do out-door work have the

benefit of fresh air and sunshine, and at the same time they get also a variety of muscular movements that give exercise to the principal groups of muscles.

It is the custom in factories to use labor-saving machinery. In operating much of this machinery there is little variety of movement, and exercise is given to only a few groups of muscles. The operator sits at his machine and feeds material to it by a few movements of the arm and the hand. The same movements are made over and over again all day long, and groups of large muscles do not get the amount of exercise they require.

Compared with this, work on a farm furnishes a much greater variety of movements. On a farm a man or a boy can get such mixed kinds of exercise as grooming horses, caring for cows and other animals, tilling soil, pitching hay or straw, sawing and splitting firewood, and pumping water. These require body-bending, lifting weights, and walking, so that abundant exercise is furnished for all the groups of larger muscles.

Games.—Play is the natural form of physical exercise for children. If they have the chance to play in safety, children will take all the exercise they require for normal, healthy development during the early years of life. Their whole time will be occupied in eating, sleeping, and playing.

At seven or eight years of age, boys and girls become interested in games in which there is competition. Some of these are tag, blackman, prisoner's base, leap-frog, and various ball games. By means of the exercise in these and other games, the

heart, the lungs, and the muscles are developed and strengthened. Bodily skill is acquired and the mind is trained in observation, in judgment, and in the power of choosing and applying proper means to get the desired results. A valuable feature of games is the interest which they excite.

After thirteen or fourteen years of age other games of a more vigorous nature claim the attention. Skating, hockey, base-ball, cricket, tennis, basket-ball, lacrosse, and foot-ball take the place of the simpler games. A feature of these games is that they are played in teams; the players no longer act separately, but unite their efforts for the benefit of their team. These contests represent the most severe form of exercise in games. Through them muscles and the organs of respiration and of circulation attain a high degree of development, and the power of endurance is acquired. Valuable habits of mind are formed by the necessity of close continued attention, quick judgment, and the nice precision required for prompt muscular action.

In learning to play these games the brain reaches a high state of development through sending out to the muscles the impulses that cause the exact movements required. This development gives increased power for prolonged and difficult mental effort in after life.

Exercise in a gymnasium.—A gymnasium has the advantage of allowing exercise to go on when the weather is unsuited to out-door games and sports. It also permits of special exercise with suitable apparatus to develop any groups of muscles that are weak and need special attention.

One form of exercise in a gymnasium consists of drills, either with or without apparatus. Such drills should be short and not too difficult. A leader should perform the movements, and the class should follow the leader. Drills sometimes consist of a long series of movements that are accurately memorized and done by silent count without any leader or word of command. These drills exhaust the nervous system by making too great demand on the memory and the power of attention.

Whenever it is possible in gymnastic exercises, the spine should be kept erect. This position gives the largest capacity of chest, and affords the greatest room for free movements of lungs and heart.

Strength is acquired slowly. It is the result of many movements, not too difficult, done daily for a considerable time. Bear in mind that strength cannot be acquired in a short time by making a few movements that require great muscular effort. Nor should the aim of exercise be the development of one or more groups of muscles in order that certain unusual feats of strength may be performed. The purpose of exercise should be to use all of the principal groups of large muscles, so that the body as a whole may be brought into the best state of health.

SUMMARY

1. The reasonable exercise of an organ strengthens it.
2. Exercise brings to a muscle a larger supply of blood, and, therefore a larger supply of food and oxygen.
3. When the muscles are exercised, there is a greater demand for food.
4. When the muscles are exercised, breathing becomes deeper and faster in order to supply needed oxygen.

5. The blood must flow faster to supply food and oxygen to the muscles during exercise. Consequently, the heart becomes more active.

6. As more food is oxidized in the muscles, a greater amount of heat is produced. The arteries of the skin dilate, and the sweat glands become more active.

7. Fatigue is due partly to the using up of food and oxygen in the muscle cells, and partly to the increase of waste products in these cells.

8. Exercise is too severe if recovery from fatigue does not follow a night's rest.

9. Exercise should be taken daily, at regular hours, and not immediately before or after a meal.

10. Exercise should produce free contraction of the groups of large muscles.

11. Manual work in the open air is one of the best forms of exercise.

12. Games are the natural exercise for children.

13. In drills the class should follow a leader, and should not be required to memorize a long series of movements.

14. Exercise should consist of easy movements frequently repeated. Movements requiring great effort should be avoided.

PART IV

THE FUNCTION OF IRRITABILITY AND CONTROL

CHAPTER XVI

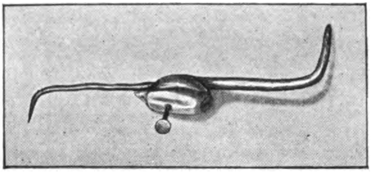
PLANT AND ANIMAL IRRITABILITY AND CONTROL

WHEN you try on a shoe that is too small for you, the pressure on your foot causes a message to go along nerves from your foot to your brain, and when the message reaches the brain you know that the pressure hurts your foot. You then send out from your brain along nerves messages directing certain muscles to raise your foot and other muscles of the hand and body to take off the shoe.

In this illustration we see two functions of our nerves. Pressure on the foot rouses to a state of activity nerves that end in its surface, and a message, or impulse as it is more often called, is conducted to the brain. These nerves are said to be irritated by the pressure, and this power of being irritated is called irritability. Anything that irritates a nerve and rouses it to activity is called a stimulus. When an impulse from the foot arrives at the brain, another impulse starts from the brain and causes muscles to act. Thus another function of nerves is to

control the action of the muscles and other organs of the body. While nerves are the special organs of irritability, other tissues are to some extent irritable, and respond to stimuli.

Plant irritability.—You remember that the active part in a living cell is the protoplasm. Now, living protoplasm, wherever found, shows some irritability, but it is not all equally irritable. The protoplasm of a living nerve cell, for instance, is much more irritable than the protoplasm of a living muscle cell, or vegetable cell. Though irritability is most noticeable in animals that have a well developed nervous system, yet it is a property of all living things, and in plants there are many interesting and wonderful instances of it.



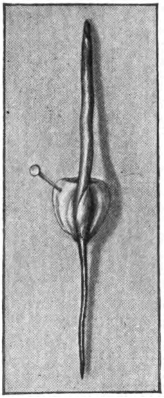
GRAIN OF CORN GROWING IN HORIZONTAL POSITION

Irritability serves a useful purpose both in the plant and the animal. If, for example, water that the plant or animal needs is near it, the water acts as a stimulus, and the plant or animal makes an attempt to get to it. If, on the other hand, there is near by something that would hurt, it acts as a stimulus, and the plant or animal makes an attempt to avoid it.

Since the plant derives its food material from the soil and the air, it receives stimuli chiefly through its leaves and the tips of its roots.

Irritability of roots, leaves, and stems.—If a kernel of corn or other seed is planted in moist sawdust, and, after it

begins to grow, is placed in a horizontal position and still kept moist, the end of the root will, within a day or two, turn downward toward the centre of the earth, and the end of the stem will turn upward away from the centre of the earth. The stimulus in these movements is gravity, the force which causes a ball that is thrown up to return to the earth. In a similar way, the end of a growing root will bend to pass a stone or other solid, to reach moisture, or to enter more fertile soil.



GRAIN OF CORN GROWING IN UPRIGHT POSITION

Another illustration of root irritability is seen in its response to the stimulus of heat. Roots will grow toward hot water or steam pipes in the soil, but will not come into contact with them. When the soil near the pipes attains a certain temperature the end of the root will cease growing toward the heat and will bend away from it. Experiments have shown that roots of Indian corn will grow toward heat until the temperature is 99.5° F., when they will bend and grow away from soil that is warmer. A writer on this subject says that the sensitiveness to heat that causes a man who is cold to approach the fire, but not to draw too close, and, when warmed, to move to a slightly cooler spot, is not peculiar to him or to other higher animals. This response to heat illustrates the habit of all living things that can move to seek positions that best promote their well-being.[1]

[1] See Peirce's *Plant Physiology*, p. 221.

Leaves are very sensitive to light. The leaves of green plants need the aid of sunlight in the manufacture of food from the materials that the plant takes from the soil and the air.

When light falls more on one side of a plant than on the other side we have a common illustration of irritability. In response to this stimulus the plant slowly bends toward the light, so that it may fall equally on both sides.

TENDRILS OF VIRGINIA CREEPER BEFORE CONTACT

Plants usually expose the broad upper surfaces of their leaves to the light, but there are plants, such as the common bean, and oxalis, that turn the broad surface of their leaves away from the light and expose an edge to it when the light becomes too strong for them.

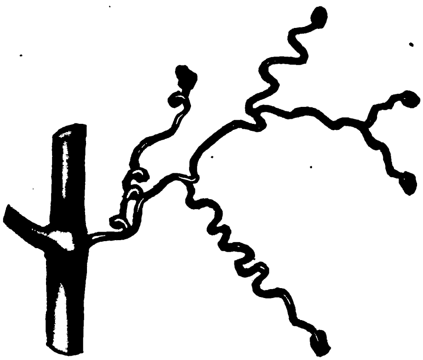
Many plants are sensitive to touch. Climbing plants, such as the hop, vine, and ivy, have stems which are not strong enough to hold the plant up so that its leaves may do their work freely in the open air and sunlight. When the stem of the hop or morning-glory comes in contact with a string or a pole, the stem responds to the stimulus of contact and closely twines for support around the object touched.

The stem of the grape-vine is not strong enough to support itself, but it produces tendrils. When a tendril of a grape-vine

touches anything that it can twine around, it slowly coils around the object, and thus affords support to the weak stem.

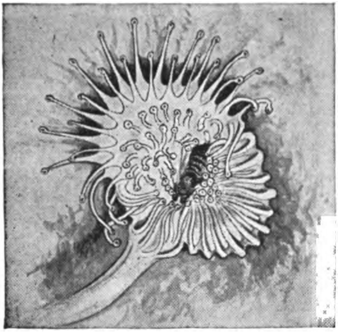
The Boston ivy and Virginia creeper are climbing plants that have tendrils. These tendrils do not coil around objects, but when the end of the tendril comes in contact with a wall or other support it secretes a sticky fluid that holds the stem fast to the wall.

Perhaps the most remarkable instances of plant irritability are seen in the movements which are made by the leaves of Venus's fly-trap and the sundew when they capture insects for food. On the outer end of the leaf of Venus's fly-trap there are three short spines that are sensitive to contact. When an insect touches one of these spines the leaf closes quickly. Numerous glands on the surface of the leaf then secrete and pour out on the captured insect a fluid that digests its nutritious parts. (See page 221.)



TENDRILS OF VIRGINIA CREEPER AFTER CONTACT

The upper surface of the leaf of the sundew is furnished with many short stalks. On the end of each stalk is a little round gland that secretes a sticky fluid and is sensitive to contact. When an insect alights on these glands it becomes entangled in the sticky secretion and

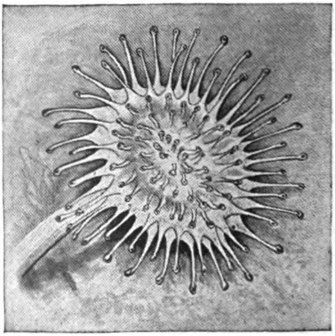


LEAF OF SUNDEW CLOSING ON CAPTURED INSECT

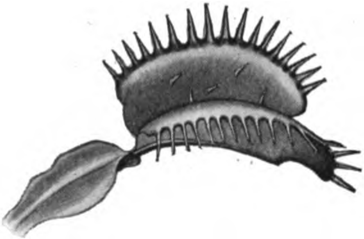
soon dies, because the fluid closes up the air tubes of the insect and it cannot breathe. The other stalks bend slowly and bring their sticky glands down upon the insect, and then the glands secrete and pour out on the insect a fluid that digests its nutritious parts.

Plants usually obtain from the soil, through their roots, the nitrogen that they need for the growth and repair of tissue. But plants like these grow on moss in marshes and cannot get enough nitrogen through their roots, and so they obtain it through their leaves from the bodies of insects.

Animal irritability and control.—In animals that consist of one cell, such as the amœba, there are no nerves. Irritability is due to the protoplasm of the single cell. Recent experiments have been conducted in order to find out in what ways these microscopic animals are irritable, and it has been shown that they respond to many kinds of stimuli. Among these are contact, heat, and cold.

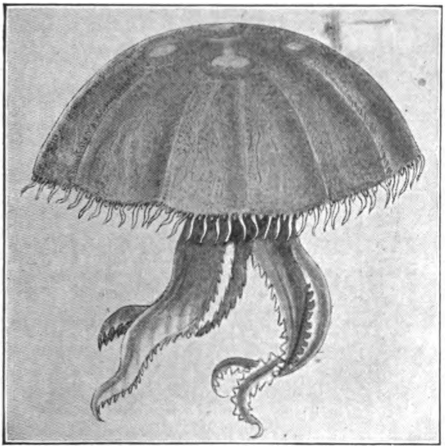


LEAF OF SUNDEW OPEN



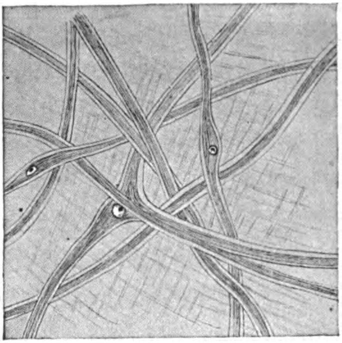
END OF LEAF OF VENUS'S FLY-TRAP

It is possible to draw out a heated glass rod into such a fine thread that its end is smaller than one of these minute animals; and when the end of such a glass thread is, with the aid of a microscope, drawn along the side of the animal, it will move away from the irritating contact. If a number of these animals are placed in water contained in a small vessel which is then heated at one end, they will move away to the other end. If one end is cooled, they will move to the warmer end. If one end is heated and the other cooled, they will move from both ends and stay in the middle.



A JELLY-FISH

As we ascend the scale of animal life, one of the first animals in which nerves have been found is the jelly-fish. This animal has an umbrella-shaped body, as shown in the picture, and on the lower side of the umbrella is a thin layer of muscle tissue. The animal moves by



NETWORK OF NERVE TISSUE IN JELLY-FISH
(Highly magnified)

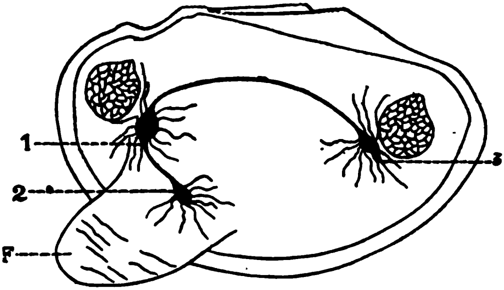
partly closing and opening its umbrella while leaning to one side. As the umbrella closes it presses against the water within it and thus forces the animal backward. The layer of muscle tissue by which these movements are made is overspread with a very fine network of nerve tissue, and this nerve tissue regulates the contraction of the muscles. It is noteworthy that in this early appearance of different kinds of tissue in the scale of animal life one kind is muscle tissue, and the other is nerve tissue whose work is to control the work of the muscle tissue.

NERVOUS SYSTEM OF A BEE

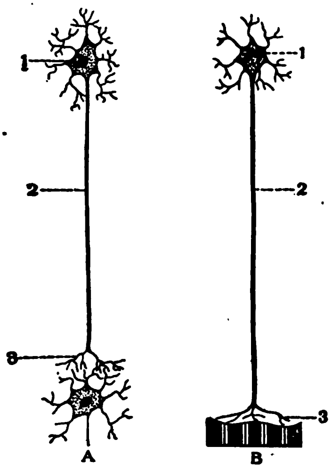
Nerve tissue.—Nerve tissue, like other tissue, is made up of cells. These cells vary greatly in size and shape, but each nerve cell is composed of two parts: one is an enlarged part containing a nucleus, which is called a nerve-cell; the other part consists of one or more projections from the nerve-cell.[1] A long projection is called a nerve-fibre. What we commonly call

[1] Observe carefully that nerve cell, without a hyphen, is used as the name of the entire cell; and that nerve-cell, with a hyphen, is used as the name of part of the cell.

nerves are nerve-fibres bound together. They are always projections from nerve-cells. Nerve-cells can both start and receive impulses. Nerve-fibres merely conduct impulses, some conduct im-



NERVOUS SYSTEM OF A MUSSEL
1. Ganglion of esophagus. 2. Ganglion of foot. 3. Ganglion of organs of digestion. (F) Foot.



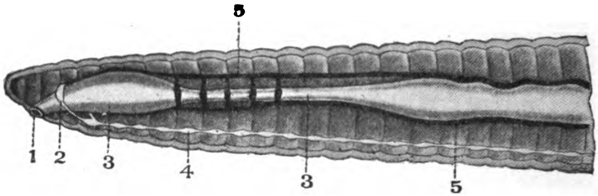
A.—NERVE CELL ENDING IN ANOTHER NERVE CELL
B.—NERVE CELL ENDING IN MUSCLE
1. Nerve-cell containing nucleus. 2. Nerve-fibre. 3. Endings of nerve-fibre.

pulses from nerve-cells and others conduct impulses to nerve cells. In these pictures, nerve cell A connects with another nerve cell; nerve cell B ends in muscle.

As we ascend the scale of life, animals become more active, and therefore require more muscle cells to produce movements, and more gland cells to furnish secretions with which to digest a larger amount of food. Consequently, muscle cells are massed together in very large numbers to form a muscle, gland cells are massed together in glands, and nerve cells are massed together

in order to control the cells of the muscles and the glands. A mass, or group, of nerve cells working together, is called a ganglion or nerve centre.

A simple kind of nervous system.—One of the simplest arrangements of nerve ganglions is seen in such animals as the oyster and the mussel. In these animals the nervous system



SECTION OF FOREPART OF EARTHWORM, SHOWING ALIMENTARY CANAL, BLOOD TUBES, AND NERVES

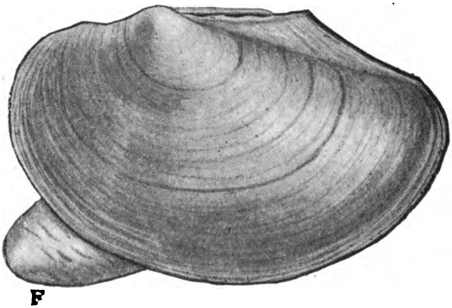
1. Mouth. 2. Nerve-ring. 3. Alimentary canal. 4. Row of ganglions. 5. Blood tubes.

consists of ganglions placed wherever an important function is located, and the ganglions are connected by nerve-fibres. A good illustration of this simple arrangement is seen in the common mussel of rivers and smaller streams. Two connected ganglions are placed either above, or on each side of, the esophagus. These send nerve-fibres to the sensitive region about the mouth. Below the esophagus are other ganglions, which send out nerve-fibres to the foot with which the animal burrows. Farther back in the body are other ganglions which send out nerve-fibres to the organs of digestion (see page 223).

A higher kind of nervous system.—A more complex nervous system is found in such invertebrate animals as the earthworm, insects, and the lobster. The bodies of such animals

are made up of a succession of parts. Each part is called a segment. There is a ganglion above and another below the esophagus. These, with their connecting nerve-fibres, form a nerve-ring, or collar, around the esophagus.

The ganglion above the esophagus, in the nerve-ring, sends off nerve-fibres to such sense organs as the eyes and the feelers in those animals that have these organs. It is also the seat of whatever instinct or intelligence the animal possesses. The ganglion below the esophagus sends out nerve-fibres to the organs that collect and masticate food, and, in some at least, regulates the movements of the body so that the different parts move together in harmony.

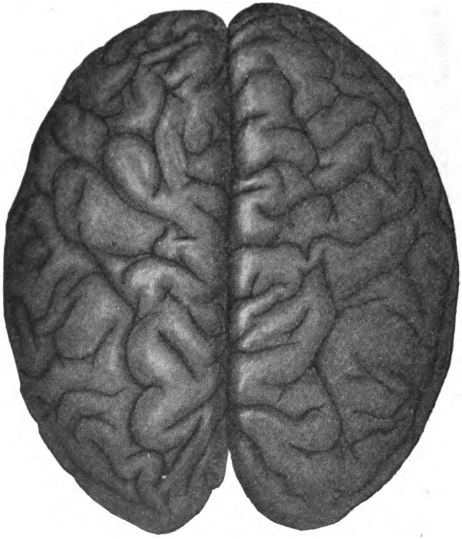


SHELL OF MUSSEL WITH FOOT PROTRUDING
(F) Foot

In addition to the nerve-ring there is a connected row of ganglions lying below the alimentary canal. This row is connected with the ganglion below the esophagus in the nerve-ring. Each ganglion in the row sends off nerve-fibres to the part of the body near the ganglion, and regulates the movements and other work of its own part.

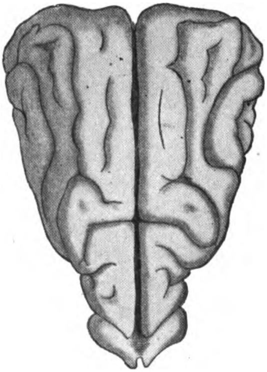
The highest kind of nervous system.—The highest kind of nervous system is found in vertebrate animals, that is, those

having a backbone, or spine. Here, too, there is a row of ganglions, called the spinal cord; but, instead of lying below the alimentary canal, it lies along the back above the alimentary canal, and for protection is placed in the cavity of the spinal column.



THE BRAIN AS SEEN FROM ABOVE

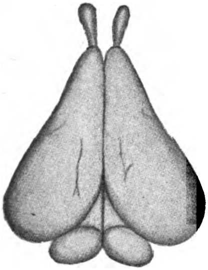
In the lowest vertebrate animals there is only the spinal cord, with nerve-fibres going off in pairs from it to adjacent parts of the body. A little higher up in the scale, however, the ganglions at the front end of the cord enlarge to form the brain, and nerve-fibres go off not only from the ganglions of the spinal cord, but also from the brain to sense organs, such as eyes and ears, and to other parts of the body.



BRAIN OF A DOG

As the brain increases in size in comparison with the rest of the body the intelligence of the animal increases, until the highest degree of intelligence is attained in man. In man the average weight of the brain is estimated to be about one-fiftieth of the weight of the rest of the body; in birds, about one-hundredth; in fishes and reptiles, about one-thousandth.

The degree of intelligence depends not alone on the comparative weight of the brain, but also on its structure. The seat of intelligence is that part of the brain known as the cerebrum. The nerve-cells of the cerebrum, in which all its activity is originated, are placed on the outer surface of the cerebrum. As animals rise in the scale of intelligence this surface is increased in extent by foldings, and consequently affords greater room for nerve-cells.



BRAIN OF A RABBIT

This difference of structure is readily observed in a picture of the cerebrum of a rabbit, of a dog, and of a man. In the cerebrum of the rabbit faint foldings appear; in the dog the foldings are quite distinct; but in the cerebrum of man these foldings are more numerous and have a much greater depth than in the cerebrum of any other animal. Thus it will be seen

that, by reason of the structure and comparative size of his brain, man rises in the scale of intelligence far beyond all other animals.

SUMMARY

1. The two functions of nerves are irritability and control.
2. All protoplasm is irritable, but the protoplasm of a living nerve cell is more irritable than any other protoplasm.
3. Irritability in the plant is greatest in the leaf and the tip of the root.
4. The tip of the root responds to such stimuli as gravity, contact with a solid, moisture, heat, and fertile soil.
5. The leaf responds to such stimuli as light and contact.
6. The leaves of the sundew and Venus's fly-trap close when insects touch them, and so secure needed proteid food.
7. Even one-celled animals respond to different kinds of stimuli.
8. The jelly-fish is one of the earliest animals in which nerves have been found.
9. Nerve tissue is made up of cells.
10. A group of nerve cells working together is called a nerve centre, or ganglion.
11. In such animals as the mussel there is a ganglion placed wherever an important function is carried on.
12. In such animals as the earthworm, insects, and the lobster, which consist of a succession of parts, there is a nerve-ring around the esophagus, and a row of ganglions below the alimentary canal.
13. In vertebrates, there is a row of ganglions, called the spinal cord, above the alimentary canal.
14. In all but the lowest vertebrates the ganglions at the front end of the cord enlarge to form the brain.
15. Animals rise in the scale of intelligence as the brain increases in size in comparison with the rest of the body, and as the foldings of the cerebrum become deeper and more numerous.

CHAPTER XVII

THE ORGANS OF THE NERVOUS SYSTEM

Controlling officers.—In every large business there is a manager, whose duty it is to give orders and to receive reports. In a railway company it would never do to let every engineer on the road run his train just when he likes. The running of the trains must be under the control of a train despatcher who has supreme command. This is necessary in order to avoid accidents and to carry on the business of the road to the best advantage.

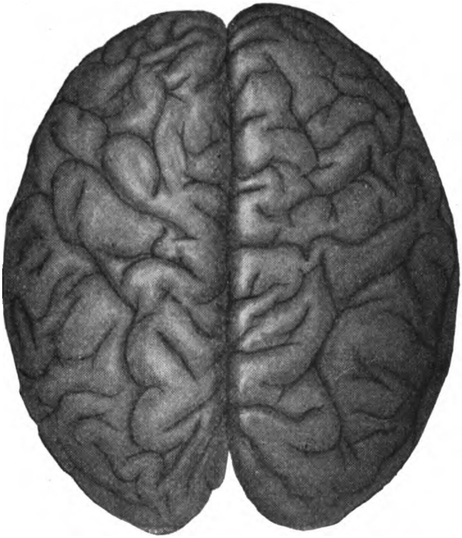
The despatcher's office is connected with every station of the road by means of telegraph wires. The despatcher can send out orders quickly to every station, and can receive reports promptly, telling him what is being done.

The controlling organ of the body.—In order that all the organs of the human body may work together for the welfare of the body there must be some central power to control their action. The brain is this central controlling organ.

Nerves extend like telegraph wires from the brain to all parts of the body, and by means of these nerves the brain can send out instantly to any part orders which we call impulses. Moreover, by means of nerves, impulses come to the brain from any part of the body; thus the brain is kept informed of what is going on in every part.

THE BRAIN, SPINAL CORD, AND NERVES

The brain.—The brain is the part of the nervous system that is contained in the skull, and is a mass of nerve cells. The brain receives a liberal supply of blood. The entire surface is

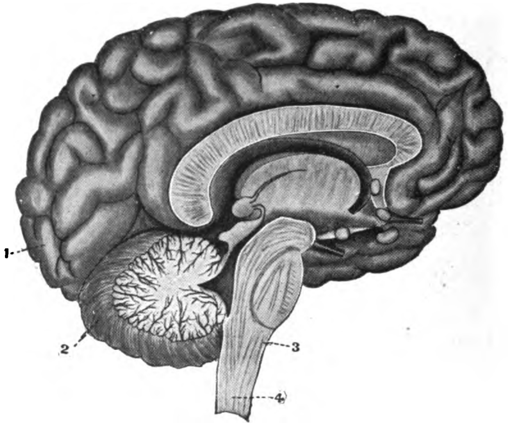


THE BRAIN AS SEEN FROM ABOVE

covered with a layer of blood tubes, which send branches to the interior to convey nourishment to the cells.

This picture gives a view of the upper part of the brain and shows the folds of its surface. These folds, or ridges, are called convolutions. This part of the brain is divided into a right and a left hemisphere by a deep furrow that extends inward to a considerable depth. At the bottom of this furrow is a thick band of nerve-fibres that pass across from one hemisphere to

the other and help to connect and hold the two hemispheres together. In this picture the bands and the parts below are cut through, so as to show the different parts of the brain. The upper folded part, which extends from front to back, is called



SECTION OF BRAIN
1. Cerebrum. 2. Cerebellum. 3. Medulla oblongata.
4. Spinal cord.

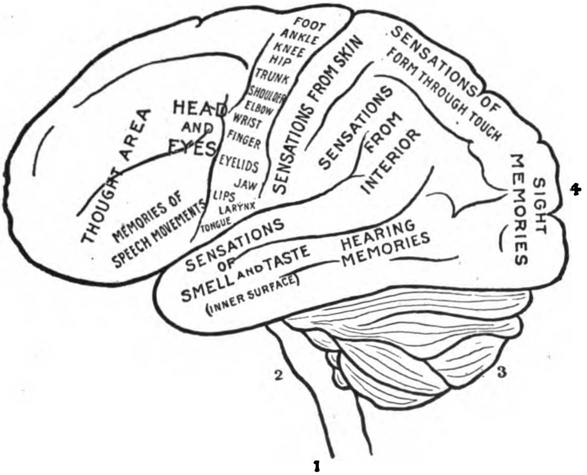
the cerebrum. The cerebellum lies under the cerebrum at the back. Just in front of the cerebellum is that part of the brain that is known as the medulla, or bulb.

The fibres of the medulla extend downward into the spinal cord. As the medulla is connected with the cerebrum and the cerebellum above and with the spinal cord below, it unites these parts and serves as the connecting link between them.

Structure of the brain.—The various parts of the brain are made up of two kinds of substance, white matter and gray

matter. The white matter consists of nerve-fibres only, the gray matter of nerve-fibres and nerve-cells. The surface of the cerebrum and the cerebellum is covered with a thin layer of gray matter, called the cortex.

The work of the cerebrum.—The cerebrum is the organ of intelligence. All acts of the mind are carried on by means of



AREAS OF CEREBRUM
1. Spinal cord. 2. Medulla. 3. Cerebellum. 4. Cerebrum

the cerebrum. It is by means of the cerebrum that we see, feel, hear, taste, smell, remember, imagine, reason, and will to do things. The cells in the cortex of the cerebrum send out impulses to voluntary muscles and cause movement. They also receive from different parts of the body impulses that cause sensation.

Impulses intended for special parts of the body, such as the hand or foot, are sent out from particular spots, or areas, in the cortex. In the diagram the part marked foot is concerned in the work of sending out impulses that control the movements of the foot. In a similar way, the areas marked knee, shoulder, finger, etc., are concerned in controlling the movements of these parts. Certain other areas of the cortex are concerned in receiving impulses from particular parts. The area, for example, marked sight memories is the part of the cortex that receives the impulses from the eye and gives rise to the sensation of sight.

The work of the cerebellum.—When the cerebellum is injured there is a lack of harmony in the movements of the body. In the act of walking, some muscles contract to lift the leg and foot; others contract and carry them forward. If the first set, by a strong contraction, should lift the foot high, while the second set, by a feeble contraction, should carry it only an inch or two forward, walking would be difficult or impossible. The two sets of muscles must act in harmony, both in regard to the time and the strength of their contractions. When two or more sets of muscles act in harmony to produce a movement they are said to be coördinated. The cerebellum is the central organ whose work is to coördinate muscular movements.

The work of the medulla.—One part of the work of the medulla is to connect the spinal cord with other parts of the brain. But the medulla continually does other important work. It contains nerve-cells arranged in groups. One group of nerve-

cells sends out impulses to control and regulate breathing. Whether we are asleep or awake, these nerve-cells send out a constant stream of impulses, and breathing goes on without interruption.

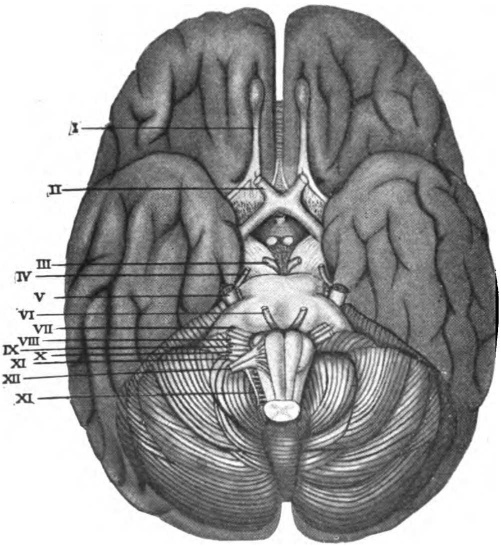
The medulla has another group of nerve-cells which send out impulses to the involuntary muscles in the walls of the arteries. This group regulates the size of the arteries throughout the body, so that the tissues and organs may receive more blood when they are active and less blood when they are inactive. The amount of blood flowing through the brain is diminished during sleep. When we go to sleep the arteries in the skin dilate and contain more blood. Less blood then goes to the brain. When we awake, impulses cause the arteries of the skin to become smaller and contain less blood. A greater supply of blood then goes to the brain while it is working.

When food comes into the mouth, impulses from the same group of nerve-cells in the medulla cause the arteries in the salivary glands to dilate and thus supply more blood to the gland cells when they are called upon to make an increased amount of saliva.

On a cold day, impulses from this group cause the arteries in the skin to contract and the skin contains less blood. Then less heat is lost from the surface of the body. On a warm day, the arteries of the skin dilate and contain more blood. The sweat glands thus receive an increased supply of blood, from which they furnish a larger amount of perspiration. As this evaporates it helps to cool the body.

The medulla contains also groups of nerve-cells that regulate such acts as sneezing, coughing, sighing, swallowing, and closing the eyelids.

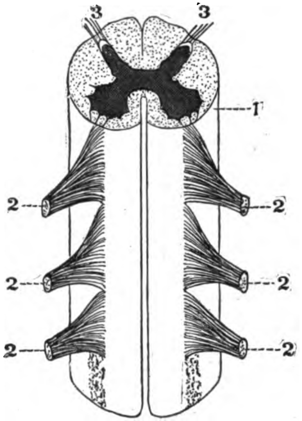
Cranial nerves.—There are twelve pairs of nerves that pass out from the brain. They are called cranial nerves. Each nerve is made up, not of a single fibre but of many fibres bound together in one common nerve trunk, just as a number of wires are bound together to form a cable. One pair of cranial nerves goes to the eyes. Another pair goes to the ears. One pair goes to the nose. Others end in the tongue and in the muscles and the skin of the face. A very important pair, called the pneumogastrics, send some fibres down the neck into the thorax to the heart and lungs, other fibres extend on into the upper part of the abdomen to end in the wall of the stomach and in the liver.



UNDER SURFACE OF BRAIN
I.–XII. Cranial nerves

This picture gives a view of the under surface of the brain, and shows where some of the cranial nerves pass out.

The spinal cord. — The spinal cord extends from the brain downward for seventeen or eighteen inches in the bony canal of the spine.



SECTION OF SPINAL CORD AND NERVES, FRONT VIEW

1. Cord. 2. Nerves of anterior root. 3. Nerves of posterior root

The sketch shows how the nerve-cells and nerve-fibres of the cord are arranged. The outer part is composed of white matter, the central part of gray matter. The outer white matter is made up of nerve-fibres only. The central gray matter consists of nerve-cells and nerve-fibres.

NERVES OF ARM
From "Gray's Anatomy"

Spinal nerves.—Nerve-fibres pass out from the sides of the spinal cord, and are called spinal nerves because they are connected with the cord. There are thirty-one pairs of spinal nerves, and they all pass outward to end in muscles, skin, and other parts of the body.

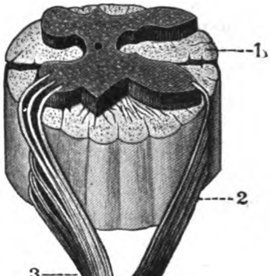
This picture shows some of the larger nerves of the arm and hand. From these larger nerves hundreds of tiny branches

pass off, some to end in the muscles of the arm and the hand, others to end in the skin that covers these muscles. The fact that it is impossible to prick the finger or arm with the point of a needle without touching one of these nerves gives some idea of the enormous number that end in the skin.

NERVES OF FOOT
From "Gray's Anatomy"

If the larger nerves of the arm were traced upward still farther, we could then follow them inward toward the spine and see where they come out from the spinal cord. They are, in fact, simply outward and downward continuations of the spinal nerves.

Here is a picture of the large nerves of the foot. They are the continuation downward of spinal nerves that come out from the lower end of the spinal cord. Fine branches of these end in the muscles and the skin of the leg and the foot.



NERVES COMING FROM THE SPINAL CORD
1. Spinal cord. 2. Posterior root. 3. Anterior root. 4 Spinal nerve

In a similar way, nerves from the middle part of the cord end in the muscles and the skin of the walls of the chest and the abdomen. Every muscle fibre and every minute portion of skin receives at least one tiny branch of a nerve.

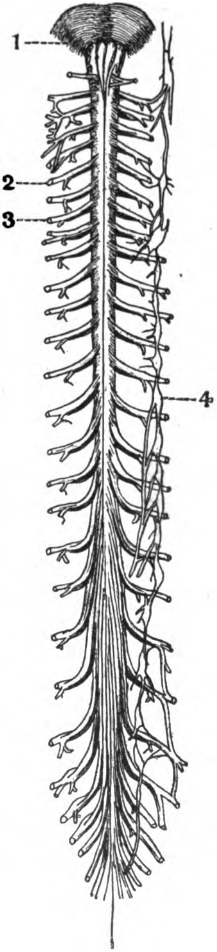
How the nerves are joined to the spinal cord.—This is a picture of the spinal cord. It shows how the upper part of

the cord is attached to the under surface of the brain.

If the cord were cut across on a level with a pair of these spinal nerves it would be seen that a bundle of fibres from the front meets a bundle of fibres from the back, and that the two bundles join just outside the cord to form a spinal nerve. Each spinal nerve, like a cranial nerve, is made up of many fibres bound together.

The bundle of fibres in front, which is called the anterior root, differs from the bundle of fibres at the back, which is called the posterior root. When, for example, you decide to move your index finger, your will starts an impulse that travels from the brain down the spinal cord, and then out along a fibre of the anterior root to the shoulder and down the arm to the finger. When the impulse reaches the proper muscles they contract and the finger is moved.

On the other hand, if you prick your finger with a needle, an impulse is thereby started that travels up the arm along a fibre of the posterior root, enters the spinal cord, and then passes up the cord to the brain. Thus all impulses going inward travel by means of the posterior root,



SPINAL CORD AND NERVES, FRONT VIEW
1. Base of brain. 2, 3. Spinal nerves. 4. Sympathetic ganglion

and all impulses going outward travel by means of the anterior root.

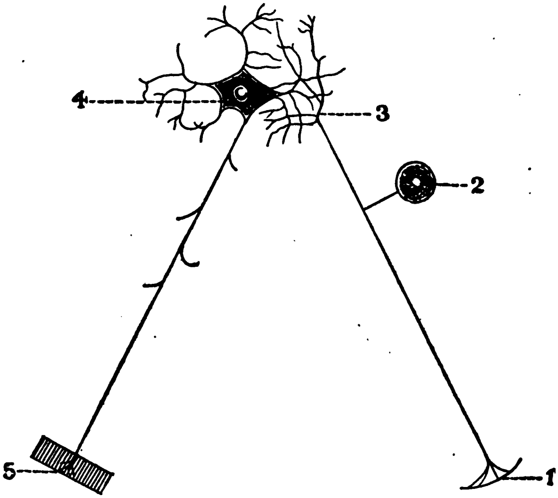
Because nerve-fibres of the anterior root conduct impulses that go to muscles and give rise to motion, these nerves are called motor nerves. Because nerve-fibres of the posterior root conduct to the brain impulses that give rise to sensations, these nerves are called sensory nerves. The motor and the sensory nerves come together and lie side by side in one common nerve trunk soon after they come out of the cord.

Reflex actions.—The fibres of the posterior root of a spinal nerve are connected indirectly in the spinal cord with those of the anterior root. A nerve impulse on coming into the cord by the posterior root may pass up the cord to the brain and not affect the fibres of the anterior root. On the other hand, while an impulse is going to the brain, it may, as it enters the cord by the posterior root, affect the fibres of the anterior root and start a motor impulse. This impulse travels out immediately to certain muscles and causes them to contract at once without waiting for an impulse from the brain. Movements that are produced in this way are called reflex actions.

Reflex actions serve to protect us from dangers. If the hand is accidentally placed on a hot object, it is jerked away quickly, even before we have time to think of what we are doing. It would take too long for a sensory impulse to travel from the hand that is in danger to the brain, and then for the brain to comprehend what is going on at the hand and send an impulse to the proper muscles to withdraw the hand; so on its way to the brain the sensory impulse starts a motor impulse and the

hand is moved away before the brain finds out what is the matter.

Another illustration of reflex action is seen in the rapidity with which the eyelids close to protect the eye from a sudden flash of bright light or from some object coming toward it.



NERVES IN SIMPLE REFLEX ACTION
1. Skin. 2. Sensory nerve-cell. 3. Terminations of sensory nerve. 4. Motor nerve-cell. 5. Motor nerve-fibre ending in muscle

When the sole of the foot is tickled, muscles of the leg contract to draw it away. These muscles will contract even when we do not wish them to contract. In many persons when the sole of the foot is tickled, muscles of the leg will contract even though every possible effort is made to prevent them from contracting. During sleep when the sole of the foot is tickled,

muscles of the leg contract and draw it away. These facts prove that the movements in such cases are brought about in a reflex way through the spinal cord, and are not the result of an ordinary impulse sent out from the brain.

The spinal cord, then, has two main functions. It serves to conduct impulses from the brain to the spinal nerves, and from the spinal nerves to the brain. It serves also the purpose of carrying on reflex action.

Habit.—When we attempt to do anything for the first time, we are conscious that we are trying to make some part of the body do what we want it to do. If we are learning to skate, we are conscious of trying to keep erect and to slide forward on the ice. Whenever we are conscious of an attempt to make some part of the body do what we want it to do, the movements of that part are controlled by nerve centres in the cerebrum. But when the movements of some part of the body, as in walking, are made without our giving attention to them, the movements are controlled by nerve centres in some lower part of the brain or in the spinal cord. Movements that are made without our giving attention to them are said to be reflex.

When an act that we have to think about is done frequently, we gradually have to think less about it than we did at first, and in time we may be able to do it unconsciously. When we were learning to walk, we had to give attention to every movement we made; but now we start in a certain direction and never think of when we should lift a foot or put it down. If friends are with us, we talk, and laugh, and think of many other

things, but never think of how we are walking. As soon as one foot touches the ground sensory impulses start from the foot along nerves toward the brain. When they reach a certain lower centre, motor impulses are started which cause muscles to raise the other foot. Walking thus becomes a series of reflex acts controlled by lower nerve centres.

In learning to write, to sew, to play a piano, to operate a typewriter, or to do anything else that requires repeated effort in learning, we have an experience similar to that in learning to walk. At first nerve impulses that cause movements travel along nerves with difficulty, for the path of the impulses is a new one. The movements are slow and deliberate. We are conscious of an attempt to make them, for they are controlled by nerve centres in the cerebrum. As, however, similar impulses travel again and again along nerves, they travel with less and less difficulty. The path is more easily traversed, for nerves tend to act more and more readily in the way in which they have acted before. In time the movements are so easily made that lower nerve centres are able to control them without the aid of the cerebrum, and the movements become reflex. The cerebrum is then free to attend to something new.

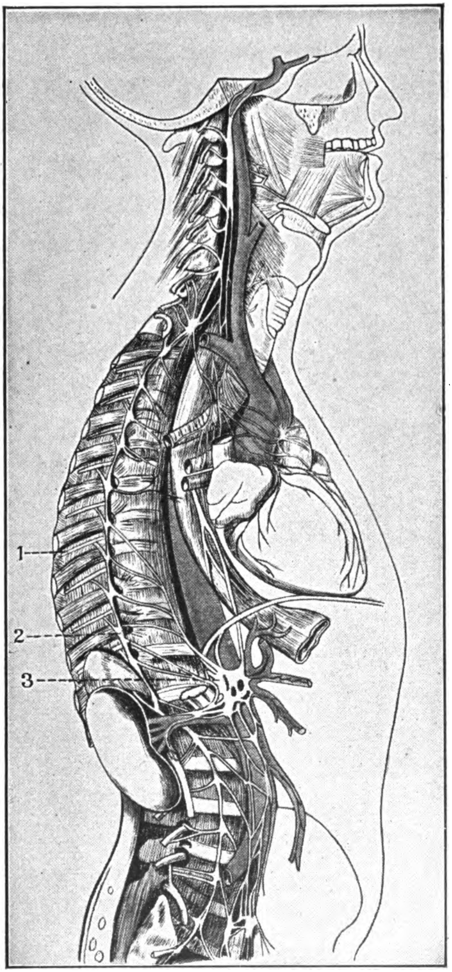
It is a very great advantage to us that lower nerve centres in time take control of movements that at first were controlled by centres in the cerebrum. It would be impossible to acquire skill in any kind of work if oft-repeated movements required the same conscious control that they require at first.

When, because of frequent repetition, a tendency to act in a

given way becomes fixed, we say that a habit has been formed. The body, or a part of it, is then ready to carry on at once its accustomed movements whenever the usual stimulus excites it. It has been truly said that we are largely a bundle of habits. We necessarily get into certain ways of doing things because we do the same thing so often. It is important, therefore, that in our first attempts to do a thing we should be careful to do it in the best way possible, in order that the best way may become a fixed habit.

The name habit is given also to many other tendencies besides those of movement. Among these are habits of manner of living, such as cleanliness and tidiness; habits of mind, such as being careful and exact; habits of conduct, such as industry, temperance, and truthfulness. All habits, both good and bad, are formed by frequent repetition; and the oftener the act that gives rise to a habit is repeated the more fixed does the habit become. It frequently happens that a harmful habit is formed that one would gladly break away from. One of the best ways of breaking away from a bad habit is to practise repeatedly something good that can take its place, in order that a good habit may replace the bad one.

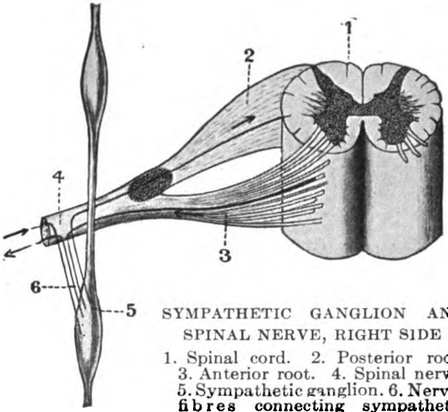
The sympathetic nerves.—In addition to the spinal and the cranial nerves, there is another distinct set that branches off from the spinal nerves to end in various internal organs and in the walls of the blood tubes. These are called sympathetic nerves. A branch from a spinal nerve joins a little knot, or cluster, of nerve-cells just outside the spinal cord, as shown in



SYMPATHETIC NERVES AND PLEXUSES
1. A spinal nerve. 2. A sympathetic ganglion. 3. The solar plexus

the picture below. This knot is known as a ganglion of the sympathetic system. There is on each side of the spinal cord a row of sympathetic ganglions connected with one another by nerve-fibres.

The picture on page 239 shows a row, or chain, of ganglions on one side of the spinal cord. There is a similar row on the other side of the cord.



SYMPATHETIC GANGLION AND SPINAL NERVE, RIGHT SIDE

1. Spinal cord. 2. Posterior root. 3. Anterior root. 4. Spinal nerve. 5. Sympathetic ganglion. 6. Nerve-fibres connecting sympathetic ganglion with spinal nerve

From these small ganglions nerve-fibres pass to join a large mass of nerve-cells and nerve-fibres known as a plexus. One of these is the great solar plexus situated behind the stomach. Another plexus is situated near the heart and is known as the cardiac plexus. Another in the neck is called the cervical plexus, and still another in the pelvis is called the pelvic plexus. These four great plexuses are situated in front of the spine. Great numbers of sympathetic nerve-fibres pass off from them to end in the involuntary muscles of various parts, such as the walls of the stomach, intestine, and blood tubes.

The sympathetic system, with its ganglions and plexuses of nerve-cells and nerve-fibres, may be considered as a development, or expansion, of one part of the spinal nerves. The office

of the sympathetic system is to supply nerve-fibres to involuntary muscles in all parts of the body for the control and regulation of their movements, and to supply nerve-fibres to the secreting glands for the purpose of controlling and regulating their periods of rest and work.

Hygiene of the nervous system.—The nervous system requires a constant and generous supply of pure rich blood in order that it may do its work well. When the blood becomes impoverished on account of an insufficient amount of food, or from any other cause, the brain suffers from starvation.

If for any reason the heart-beats become so feeble that a much smaller stream of blood than usual is sent to the brain, a sensation of faintness is felt. Total loss of consciousness follows quickly if this condition continues. The cerebrum cannot do its work unless it has a sufficient supply of blood.

The brain is very sensitive to the presence of poisons in the blood flowing through it. Impure air affects the brain. An excess of carbon dioxide, or a diminished amount of oxygen in the air we breathe, gives rise to headache and drowsiness and interferes with the normal working of the brain.

Exercise of the brain.—The brain, like the muscles, needs exercise. Physical work strengthens the muscles and gives us increased physical power; mental work develops the brain and gives us increased mental power. In order to develop the brain, mental work should be done in a regular, systematic way.

Intense brain work of any kind, if prolonged, exhausts the supply of food contained in the blood and impairs the whole

system. Pupils with frail bodies and bright minds should be careful to avoid prolonged mental effort. Only those that have well-developed, vigorous bodies should ever be allowed to compete for prizes given as a reward for study.

Too much time is often given to the mere study of books. An occasional day may be spent with profit among the hills, studying the rocks, springs, and soils; or in the woods, enjoying the trees, birds, and flowers.

Brain rest.—Regular times for rest, as well as regular times for work, are necessary, in order to have a healthy, vigorous, nervous system. The brain and nerves need rest just as muscles need rest. If muscles that have been vigorously exercised are tired, stiff, or sore after a reasonable period of rest, the exercise was too severe or too prolonged. Mental work, such as hard study, exhausts the brain and gives rise to a feeling of fatigue that should entirely pass away after a period of rest and sleep. If the following morning does not find us refreshed and able to renew our study with comfort, the mental work of the day before was too severe or too prolonged.

Brain rest does not mean a state in which the brain ceases to do any work, for during waking hours it is always working, and even while we are asleep it is not entirely inactive. One way to rest the brain is to change from our regular work for a short time to something else that will afford pleasant relaxation. It has been found by experience that even short periods of relaxation, if spent in the fresh air and accompanied by bodily activity, will do much to rest the brain and restore it to its

normal vigor. After a period of hard mental effort the mind will find rest in games such as tennis or basket-ball, or in light gardening. Indoor games, inexpensive pastimes, cheerful companionship, music, and various other forms of entertainment afford suitable recreation after the care and toil of the day.

Sleep.—Sleep furnishes the most complete and perfect rest for mind and body. Some persons need more sleep than others. Those that do mental work require more sleep than those that are engaged in physical work. Most grown people require from seven to nine hours of sleep a day. Children, however, need more sleep than grown people do. At the age of four years, eleven or twelve hours of sleep are required; from the ages of six to ten years, ten or eleven hours should be given to sleep; and from ten to sixteen years, nine hours of sleep are required.

Regular hours for going to bed and for rising favor sleep. If one has good health, exercise in the open air, suitable games, and work that is not too laborious are also favorable to sleep. Fatigue, if it is not too severe, promotes sound, refreshing sleep, while idleness prevents it.

Among the many ways in which sleep may be disturbed are indigestion, lack of fresh air in the sleeping-room, excessive bed clothing, or cold feet. Sleep may be disturbed also by distressing dreams, which are sometimes caused by exciting stories read or heard just before bed-time, or by play that is too exciting in the evening. Worry is a frequent cause of disturbed sleep. One is fortunate if he can dismiss all cares from his

mind when he rests his head on his pillow. Every one should try to cultivate this habit.

Boys and girls in school are sometimes expected to do as home-work tasks that are too difficult for them. After an evening spent in unsuccessful efforts to solve a number of long and difficult problems in arithmetic, or to unravel a number of involved sentences in grammar, the mind is liable to be too much excited for restful sleep. The consequence of failure in class often adds to the worry and renders sound, refreshing sleep impossible. All tasks that are required of children, both at school and at home, should be difficult enough for earnest effort in their performance, but should not be so difficult as to discourage a child by requiring what is beyond his power to accomplish.

Headache.—The most common causes of headache are eye-strain, indigestion, constipation, worry, and breathing bad air. Eye-strain is probably the most common cause of constant or recurring headaches. The muscles or nerves of the eye often become fatigued from improper use of the eye, or from some defect in the eyeball, such as near sight or far sight. When eye-strain is due to a defect of the eyeball, it may be lessened or overcome, and the headache be prevented, by the use of spectacles that are accurately and carefully adjusted.

Another cause of headache is indigestion from improper food, such as unripe fruits, or pastry, from overloading the stomach, and from the habit of swallowing food without taking time to chew it well. Headaches from such causes may be prevented

by eating a proper amount of suitable food at regular intervals, and by taking time to chew it thoroughly.

Undigested portions of food are not absorbed, but pass out of the intestine as useless material. If the intestine is not relieved of this useless material at proper intervals, the condition is called constipation. Constipation is a cause of headache, dulness, fretfulness, and disturbed sleep, and is frequently the result of indigestion. Care should be taken to establish the habit of getting rid of this useless material every day.

SUMMARY

1. The brain is the controlling organ of the body.
2. By means of nerves, the brain sends out orders to all parts of the body, and also receives messages from them.
3. The upper part of the brain, or cerebrum, is divided into two hemispheres.
4. The cerebrum is the organ of intelligence.
5. Impulses from certain areas of the cortex go out to particular parts of the body.
6. Impulses from different parts of the body are received at different areas of the cortex.
7. The function of the cerebellum is to coördinate muscular movement.
8. Among the functions of the medulla are the control of breathing, and the regulating of the size of arteries and consequent supply of blood to different organs.
9. Cranial nerves pass out from the brain; spinal nerves pass out from the spine.
10. The nerve-fibres of the anterior root of a spinal nerve conduct impulses outward, and are called motor nerves.
11. The nerve-fibres of the posterior root of a spinal nerve conduct impulses inward, and are called sensory nerves.

12. There are two principal functions of the spinal cord: to conduct impulses, and to carry on reflex actions.

13. The sympathetic nerves branch off from the spinal nerves and end in different internal organs and in the walls of the blood tubes.

14. A mass of sympathetic nerve-cells and nerve-fibres is called a plexus.

15. Faintness, or unconsciousness, may arise if there is not a sufficient supply of blood to the brain.

16. Exercise of the brain strengthens it.

17. The brain and nerves need rest. The best rest is obtained from sleep.

18. Two common causes of headache are indigestion and eye-strain.

CHAPTER XVIII

THE EFFECTS OF NARCOTICS ON THE NERVOUS SYSTEM

Effects of alcohol.—Alcohol is especially harmful to the tissues of the nervous system, the delicate cells of the brain being easily injured by it. When a moderate amount of alcohol is taken there is, at first, a feeling of mild excitement. The mind appears then to work more rapidly and easily than usual. For this reason some are led to believe that alcohol enables them to think better and more quickly.

It has, however, been proved by careful experiments that alcohol enables the mind to work more rapidly only in the simplest forms of mental work, such as the recognizing of signs displayed for that purpose, and then only for a short time. After a brief lapse of time there is a slowing down of the mind even in performing the simplest mental acts. In more difficult acts that require comparison, memory, or judgment, the mind works more slowly from the beginning, although the person thinks his mind is working more rapidly. A common effect of alcohol, when taken in small quantities, is to deceive those who take it. They feel that the brain is extraordinarily active, and that they are thinking more rapidly than usual, whereas they are really thinking more slowly than usual.

In such cases the harmful effect of alcohol on the protoplasm of the brain cells is similar to the action of ether, chloroform, and other narcotics that dentists and surgeons use to make people unconscious. When these drugs are beginning to paralyze the brain cells, the patient often feels that he is stronger and that his mind is more active than usual.

When alcohol is beginning to injure the brain cells, the first powers of the mind to be lost are the finer ones of judgment and reason. These preserve what is called the "normal balance of the brain," and serve to put restraint upon our actions. It is by means of these powers that we consider the prudence and propriety of our actions. When a small amount of alcohol is taken these powers are impaired temporarily. The usual restraint is gone, and a man becomes reckless, saying and doing things he would not if the cells of his brain were not injured and made incapable of doing their usual work. The power of judgment, too, is lost. A man will think he is singing well or speaking eloquently, while those around him cannot help a feeling of pity because the alcohol has so unbalanced his mind. It is because of this impaired judgment that a man is deceived and led to think his mind is working more rapidly after taking a small amount of alcoholic liquor, whereas all the time it is working more slowly.

If the amount of alcohol is sufficient to produce intoxication, the nerves that control muscles will next be injured. Speech will then become thick, the gait will be unsteady, and the movements of the eyes and eyelids in winking and seeing will be ir-

regular. The sense of touch and other special senses will be blunted, and there will be a tendency to sleep. If a very large amount of alcohol is taken the nerve centres in the medulla that control circulation and breathing may be paralyzed, and the result may prove fatal.

Another evidence of injury to the brain cells of one who has acquired an appetite for alcoholic liquors is the weakened state of his will. As the habit grows upon him, his will power becomes weaker and weaker until it seems impossible for him to muster up sufficient determination to break away from the habit which he knows is destroying him.

Life insurance and alcohol.—In England, Scotland, Canada, and Australia, there are life insurance companies that separate their business into two sections. In one section they insure lives of abstainers, *i. e.*, those who do not drink alcoholic liquor. In the other section they insure lives of moderate drinkers of alcoholic liquor. In all these companies it has been found that, on the average, abstainers live longer than moderate drinkers. This result would not mean so much if the companies were careless in insuring moderate drinkers. They are, however, so careful that the average life of the moderate drinkers they insure is as long as the average life of the men that are insured in other companies that make no distinction between abstainers and moderate drinkers.

As a result of long experience, insurance companies have made up what are called tables of mortality. These tables show how many of a given number of persons having the same

age may be expected to die each succeeding year. From these tables the companies estimate the yearly expenses they will have to meet because of deaths.

The largest of the companies that insure in two sections is the United Kingdom Temperance and General Provident Institution, of London, England. This company estimates the number of expected deaths by using the same tables of mortality that other insurance companies use. During forty-one years—1866 to 1906 inclusive—the number of expected deaths in the abstainers' section was 10,889, while in the section of moderate drinkers it was 13,952. The actual number of deaths among the abstainers was 7,760, or 71.26 per cent. of the expected number. Among the moderate drinkers the actual number of deaths was 13,188, or 94.52 per cent. of the number expected. The rate of death, therefore, among the moderate drinkers was nearly one-third greater than the rate among the abstainers.

In these companies the longer life of abstainers is recognized in a business way. Some of them insure abstainers at a lower rate than they insure moderate drinkers; others insure at the same rate in both sections, but pay a larger share of profits to the abstainers.

Tobacco.—Tobacco is a mild narcotic. It contains a small amount of a powerful poison called nicotine. In chewing, the saliva dissolves out part of the nicotine, and it passes through the mucous membrane lining the mouth into the small blood tubes, where it mingles with the blood. In smoking, some of the nicotine is changed to vapor, while part of it is changed into

an even more powerful poison called pyridine. Some of these poisons in the smoke pass into the small blood tubes of the mouth, and so mingle with the blood.

Tobacco does not affect all people in the same way. When it is first used its poisonous effect is often very marked; but many persons soon become accustomed to its moderate use, and do not suffer any immediate injurious effect. Still, the moderate use of tobacco for years may give rise to serious consequences, and it is probable that most grown persons would feel better if they did not use it.

There are, on the other hand, many whose bodies cannot resist the poison of tobacco, and its use gives rise to a trembling of the hands and limbs, to giddiness, sleeplessness, catarrh of the mucous membrane of the throat, indigestion, or irregular beating of the heart. These symptoms disappear when the use of tobacco is discontinued.

It is said by eminent physicians that a chance sore in the mouth from biting the tongue or cheeks, or from some sharp tooth, is frequently so irritated by the poison of tobacco that a cancer is produced at the injured part.

It is well known also that the use of tobacco may cause a disease of the optic nerve at the back of the eyeball and cause either impaired vision or total blindness.

It is quite certain that the use of tobacco in any amount and in any form is injurious to young growing persons. The immature nervous system is unable to resist its poisonous effects. The injury from tobacco is greatest when it is used by boys of

tender years. Yet in colleges, where young men are approaching maturity, the injurious effect of the use of tobacco is readily observed. In Yale and other colleges, careful measurements have shown that growth in weight, height, and girth of chest is greater among students that do not use tobacco than among those that do use it.

Cigarettes.—Cigarettes are a great evil, for they enable young persons to acquire easily the habit of using tobacco. The harmful effects that cigarettes produce are due solely to the nicotine that they contain.

The smallness and mildness of cigarettes conceal their capacity for doing harm. When a boy begins the use of tobacco by chewing, or by smoking a pipe or cigar, he usually experiences very uncomfortable feelings because of nicotine poisoning. Faintness, dizziness, nausea, extreme weakness, and vomiting are some of the more usual effects. But the first cigarette, on account of its smallness and mildness, seldom gives rise to these deathly feelings. In a short time, one cigarette fails to satisfy the smoker, so he gradually comes to smoke a great number, and thus a large amount of nicotine is absorbed each day.

In the case of some drugs, if the ordinary dose is divided into a number of equal parts, and one part is given every ten minutes until all are given, the effect produced is much more powerful than it would be if all were given at once. This is the case with nicotine. The dose of nicotine in each cigarette is small, but, by its frequent repetition in smoking a number of cigar-

ettes in a short time, the poisonous effect of the nicotine is greatly increased.

The amount of nicotine that is absorbed depends upon the extent of surface with which the smoke comes in contact. Cigarette smokers, as a rule, inhale the smoke so that it comes in contact with the mucous membrane not only of the mouth, but also of the larynx, windpipe, and larger bronchial tubes. The surface , therefore, that smoke comes in contact with when it is inhaled is about three times as great as in ordinary smoking. The small cigarette, then, is not so weak as it appears.

When we remember the number of cigarettes that are often smoked in one day, the increased effect from frequently repeated doses, and the extra amount of poison that is absorbed through inhaling the smoke, it is not hard to see why cigarettes bring ruin to so many of the unfortunate boys that become addicted to them.

Tobacco and the heart.—Tobacco often affects the nerves that control the beating of the heart. The leading symptom in this condition is palpitation. In its mildest forms there is a slight fluttering and a sense of discomfort about the heart. In more severe attacks the beating of the heart is at times weak and irregular; at other times it is stronger and more rapid than usual and may be accompanied with considerable pain. These uncomfortable symptoms disappear very quickly when the use of tobacco is discontinued.

Narcotics.—Drugs that numb the brain are called narcotics. They lessen the power to feel and think, and in large doses produce sleep.

Opium is a familiar example of a drug belonging to this class. Nicotine is a powerful narcotic. Alcohol, also, is a narcotic, for, as we have learned, in large quantities it produces sleep, and in smaller amounts it numbs the brain and nerves.

Some narcotics are useful as medicines to relieve pain, but they all tend to injure the health if taken habitually. The greatest danger connected with the use of small doses of narcotics is their power to create an irresistible craving for more. This makes it difficult, or almost impossible, to discontinue their use after the habit of taking them is once formed.

Opium.—The principal drugs made from opium are laudanum, morphine, Dover's powders, and paregoric. They all relieve pain and give a feeling of comfort. This feeling soon passes off and is followed by depression and a feeling of weakness, which makes it easy to repeat the dose in order to secure relief. In this way, the habit of taking any of these drugs may become fixed before one is aware of his danger. Efforts to break off the habit are very often not successful, for narcotics injure the cells of the nervous system and weaken the power of the will.

Danger of giving opium to children.—Opium in the form of laudanum or paregoric is sometimes given to infants to quiet them when crying, or to cause them to sleep. Soothing syrups, teething powders, and cordials usually contain opium in some form, and for this reason they should never be given to infants or children. They simply numb the brain, and take away, for a short time, the power to feel pain. Children are

often seriously and even fatally injured by such use of opium or drugs that contain it. No medicine containing opium in any form should ever be given to a child except by the advice of a physician.

Chloral hydrate, cocaine, bromides, and headache powders.—These drugs may be useful as medicines when properly given, but they are liable to do great harm if used by those who are ignorant of their action. Moreover, the temptation to repeat the dose makes it easy to form the habit of taking them. The only safe rule regarding all such drugs is to let them entirely alone unless they are prescribed by a physician.

The following is quoted from the New York *Times* of August 5, 1906, and is part of an interview with Luther Burbank by Champ Andrews:

"'Do you think that whiskey and tobacco impair the faculty for work?' I asked. He replied: 'If I answered your question simply by saying that I never use tobacco and alcohol in any form, and very rarely either coffee or tea, you might say that was a personal preference and proved nothing. But I can prove to you most conclusively that even the mild use of stimulants is incompatible with work requiring accurate attention and definite concentration. To assist me in my work of budding—work that is as accurate and exacting as watchmaking—I have a force of some twenty men. I discharge men from this force at the first show of incompetency. Some time ago, my foreman asked me if I took pains to inquire into the personal habits of my men. On being answered in the negative, he surprised me by saying that the men I found unable to do the delicate work of budding invariably turned out to be smokers and

drinkers. Even men who smoke one cigar a day I cannot entrust with some of my delicate work. Cigarettes are even more damaging than cigars, and their use by young boys is little short of criminal.' "

According to the letters given below, the Hon. Willard H. Olmsted, Judge in the Children's Court of New York, and the Hon. Richard S. Tuthill, Judge in the Juvenile Court of Chicago, find that cigarette smoking is common among the boys that are brought before them for trial. It is a fair inference that the habit of smoking cigarettes is, in no small measure, responsible for the anæmic, poorly nourished condition of those boys.

NEW YORK, *January* 11, 1909.

Dear Sir:—I have yours of January 6, making inquiry concerning the effects of cigarette smoking in the matter of children who are so unfortunate as to be arraigned in the Children's Court.

Not being a physiologist, it would be difficult for me to determine whether cigarette smoking is a cause or an effect. It is certainly a fact, however, that I have found cigarette smoking prevalent among delinquent children, and in most cases children who were addicted to that habit were apparently anæmic and ill-nurtured.

I am,

Very truly yours,

WILLARD H. OLMSTED.

CHICAGO, ILL., *January* 19, 1909.

Dear Sir:—An experience with delinquent children, especially with delinquent boys, extending over a period of more than twenty years, (1) as president of a city shelter and school for the homeless, runaways, and strays found in a great city; (2) as Judge for ten years of the Juvenile Court from its creation in 1899; and (3) as a

trustee of the St. Charles School for Boys, a State farm caring for delinquent boys from one hundred and two counties of the State, warrants me in saying that I have found the pernicious habit of cigarette smoking among these boys almost universal.

The great majority of them have been apparently anæmic and ill-nurtured, and I have observed in them a retarded and interrupted growth physically, morally, and mentally.

Very truly yours,

RICHARD S. TUTHILL.

SUMMARY

1. The delicate cells of the brain are easily injured by alcohol.
2. The drinking of even small amounts of alcohol lessens the working power of the mind.
3. In intoxication, the earliest injury to the brain impairs the finer mental powers of judgment and reason.
4. The nerves that control muscles are the next to be injured.
5. The drinking of a large amount of alcohol may affect the nerve centres that control circulation and breathing, and may cause death.
6. The continued use of alcoholic liquor may destroy the power of the will.
7. Tobacco contains a powerful poison called nicotine.
8. Nicotine interferes seriously with growth.
9. The most harmful form of tobacco is the cigarette.
10. Tobacco may injure the nerves that control the beating of the heart.
11. The use of any narcotic drug may give rise to a strong craving for it.

CHAPTER XIX

THE FIVE SPECIAL SENSES

Information from the outside world.—You will remember that the brain receives information from all parts of the body. It receives information also in regard to what is happening outside the body. The ends of some nerves lie just under the scarf-skin, the ends of some are in the tongue, some are in the nose, some are in the eyes, some in the ears. Anything from the outside world that acts on these nerves starts an impulse which they conduct to the brain. There are five different sets of nerves over which impulses thus come to the brain. We say, therefore, we have five special senses—touch, taste, smell, sight, and hearing. It sometimes happens that nerves leading from some organ of the body to the brain are injured so that they will not conduct an impulse to the brain. It may be that the nerves that conduct impulses from the eyes to the brain become unable to do their work. Then we are blind, and we get through our eyes no idea of the things that other people see.

While it is by means of our nerves and brain that we touch, taste, smell, hear, and see, yet the arrangement of the nerve endings is so different for each sense that each must be considered by itself.

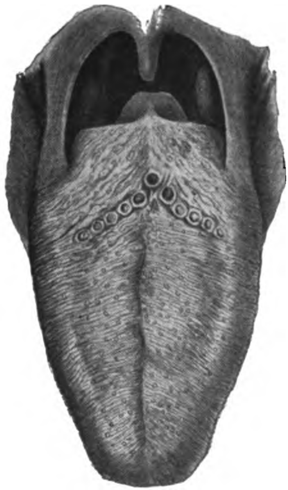
The sense of touch.—Objects that make pressure on the skin start impulses in nerve endings in the skin. These im-

pulses go from the skin to the brain along sensory nerves, and in the brain the impulses give rise to sensations of feeling. By means of such sensations we learn much regarding the nature of objects that are in contact with the skin. We learn, among other things, whether an object is rough or smooth, hard or soft, hot or cold. We also learn of its surface, edges, size, shape, and, to some extent, of the material of which it is composed. Excessive pressure, heat, or cold gives rise to sensations of pain. Slight pressure, as with a feather, produces a sensation which we call tickling.

All parts of the skin are sensitive to contact and pressure, but some parts are more sensitive than others. The most sensitive parts are the tips of the fingers, lips, tip of the nose, and palms of the hands. Nerve endings are more numerous in the skin of these parts than in the skin of less sensitive parts.

Muscular sense.—Impulses reach the brain from the muscles. From such impulses we gain a knowledge of the condition of our muscles and know to what extent they are contracted. In lifting objects we are able to judge of their weight by the amount of resistance offered to the muscles as they contract.

The sense of taste.—The organs of the sense of taste are the tongue and the back part of the mouth. These parts, like the skin, contain little raised points called papillæ. From eight to twelve large papillæ can be seen at the back of the tongue. They are arranged in the form of the letter V. Many smaller ones are scattered over the sides and the tip of the tongue, and also on the palate and the back part of the mouth. Nerve-



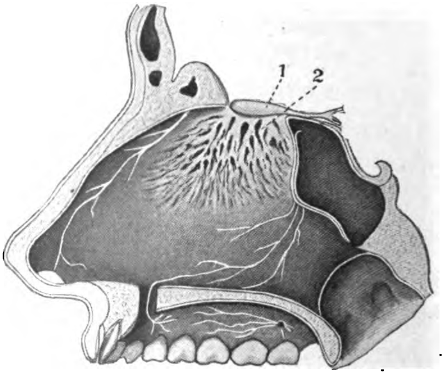
THE TONGUE AND PAPILLÆ

fibres end in these papillæ and conduct to the brain impulses that give rise to sensations of taste.

We are unable to taste solids. They must be dissolved in saliva or other liquid before they can be tasted.

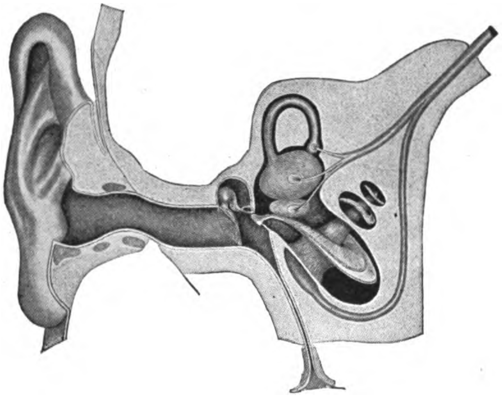
The four principal sensations of taste are bitter, sweet, acid or sour, and salt or saline. Such substances as onions, which have a strong odor, are recognized in the mouth by their odor and not by their taste. When the nose is held tightly, so as to interfere with the sense of smell, it is difficult, or impossible, to tell a piece of onion from a piece of apple when placed on the tongue.

The sense of smell.—The fibres, or branches, of the nerves of smell, called the olfactory nerves, are spread out on the soft lining of the upper part of each nostril. They extend from the brain to the lining of



END OF OLFACTORY NERVE AND ITS BRANCHES
1. Nerve. 2. Branches

the nose. Sensations of smell are produced by the action on the olfactory nerve-fibres of gaseous, odorous substances in the air we breathe. During inspiration a current of air streams through the nasal passages and the odorous substances it con-



SECTION OF EAR

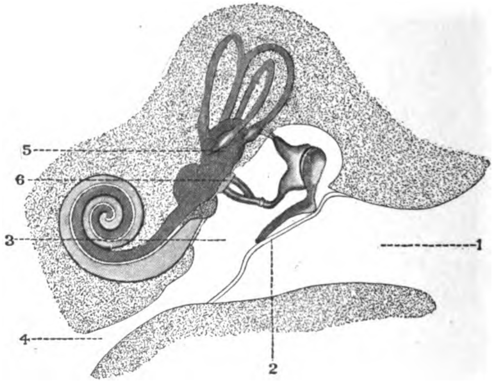
tains come in contact with the nerve endings in the soft lining of the nose. Impulses travel along the nerves to the brain and give rise to sensations of smell.

Some injurious gases in the air we breathe may be detected by the sense of smell. This sense, aided by the sense of taste, assists us in the selection of food, and is, moreover, a source of considerable pleasure.

The sense of hearing.—The auditory nerves end in the ears. They conduct impulses from the ears to the brain. When these impulses reach the brain they give rise to sensations of sound.

For convenience of description the ear is divided into three parts, the external, the middle, and the internal ear.

This picture shows how these parts are arranged in relation to one another. The external ear consists of the visible part, which is commonly meant when one speaks of the ear, and a



MIDDLE AND INTERNAL EAR

1. External ear. 2. Drum membrane. 3. Middle ear. 4. Eustachian tube. 5. Interior ear. 6. Stirrup bone and membrane to which it is attached

canal extending inward a little more than an inch to a membrane, called the drum membrane, which completely separates the external from the middle ear.

The middle ear, or drum, is a small cavity in a bone on the side of the skull, and lies between the external and the internal ear. The middle ear resembles a drum because it has this drum membrane stretched across its outer end like a head of a drum. In the middle ear is a chain of three small bones—the hammer, the anvil, and the stirrup. The hammer is fastened

to the drum membrane; the anvil comes next, lying between the other two; and the stirrup connects at its outer end with the anvil, at its inner end with the membrane that is stretched across a small opening into the internal ear.

The middle ear contains air which enters from the throat by the Eustachian tube. The drum membrane needs air on both sides of it so that it may vibrate freely. If the air pressed on the outside only, the membrane could not vibrate.

The internal ear is called the labyrinth, because it is so complicated in arrangement. It consists of three parts, or cavities —the semi-circular canals above, the vestibule in the centre, and the cochlea, or snail-shell below. All these cavities are connected with one another, and are filled with a watery fluid called lymph.

The auditory nerve divides into three main branches. One branch enters each part of the internal ear. The fine endings of the nerve float in the lymph.

By following the pictures closely it is easy to understand how each part assists in the production of sensations of hearing. Sound-waves, *i. e.*, vibrations of air, enter the external ear and strike against the drum membrane at the inner end of the canal. This causes the membrane to vibrate. The vibrations of the drum membrane set the small bones of the middle ear in motion. The movements of these bones cause vibrations of the membrane that closes the opening into the internal ear. As this membrane vibrates it beats against the lymph in the internal ear and causes little wave movements of the lymph. The waves

of lymph, beating against the auditory nerve endings, start impulses that travel to the brain and give rise to sensations of hearing.

Care of the ears.—The best way to care for the ears is to leave them entirely alone. The outer end of the canal of the external ear may be cleaned when necessary, with a soft, damp cloth. Nothing else should be put into the ears under any circumstances unless by the advice of a physician.

The canal is lined with skin that contains glands. These glands secrete the ear wax. Usually the wax does not accumulate but passes out of the canal as it is secreted. Occasionally, however, the wax remains in the canal, and, forming a plug, interferes with hearing.

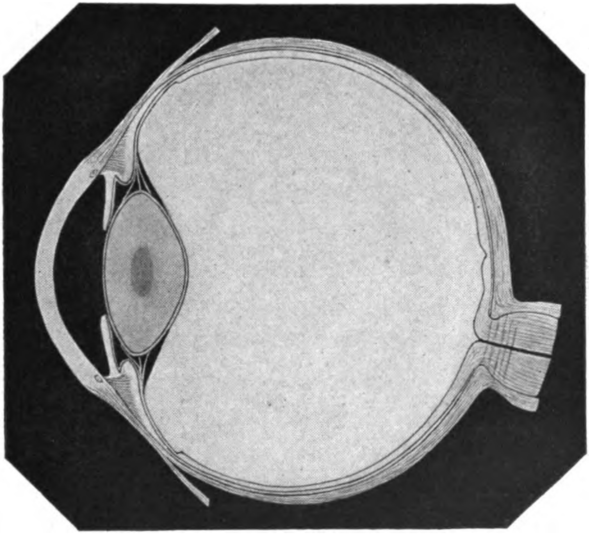
Such foreign bodies as peas, beans, buttons, wads of paper, and the like sometimes get into the ears. Bugs and insects occasionally crawl into the ears. The wisest course under these circumstances is to consult a physician, instead of making a bad matter worse by clumsy attempts to remove the intruding object.

If the aid of a physician cannot be obtained, warm water may be carefully and slowly injected, without force, into the canal. Use an ear syringe for this. Care must be taken to place the nozzle of the syringe so as to direct the stream between the object and the skin, and not directly against the object, or it will be driven farther in. Never attempt to remove anything from the ear with a match, pin, lead pencil, knitting needle, or any similar instrument.

A blow on the ear with the palm of the hand may rupture a

drum membrane and diminish the power of hearing for life. Children sometimes shout in each other's ears in play. They should not do this.

The sense of sight.—The eye is the organ of sight. This picture shows the arrangement of the various parts of the eye-



THE COATS OF THE EYE

ball. The wall at the back is made up of three distinct coats, the sclerotic, the choroid, and the retina.

The optic nerve enters from behind and the fibres are spread out in the retina or inner coat. The interior of the eye contains a watery fluid, called the aqueous humor, the lens, and a jelly-like substance, called the vitreous humor.

Parts of the eyeball.—The outer coat of the eyeball has two names: the cornea, for the front part, and the sclerotic, for the back part. The cornea is transparent like glass, and bulges slightly forward like the crystal of a watch. The sclerotic, or white of the eye, extends backward from the cornea and is opaque. The sclerotic and the cornea together form a thick, tough covering that supports and protects the delicate structure of the eye.

The choroid coat lies just inside the sclerotic. It consists of blood tubes held together with a small amount of connective tissue, and extends as far forward as the iris.

The iris.—The iris is a thin circular curtain with a central hole, the pupil. When you look at your eyes in a mirror the pupil appears as a dark, round spot in the centre of the colored part of each eye. The colored part is the iris. It lies behind the cornea, and in front of the lens. Its outer edge connects with the choroid; its inner edge forms the margin of the pupil.

The iris contains coloring matter that gives the eye its color. It is well known that the color of the eye varies in different individuals. Owing to this coloring matter, light cannot pass through the substance of the iris, but must pass through the pupil in order to reach the retina at the back of the eye.

The size of the pupil varies from time to time. In a bright light the pupil contracts and prevents too much light from entering the eye. In a dim light it dilates in order that more light can enter.

The lens.—The lens lies behind the pupil. It is clear and transparent like glass, and is surrounded by a thin membrane called the capsule of the lens. It is convex both on its front and on its back surface, and is held in place by the ligament of the lens, which is inserted into the choroid coat.

The aqueous humor.—The watery fluid called the aqueous humor fills a small chamber in the front part of the eye between the cornea and the lens. The iris divides this chamber into two parts. The part that lies between the iris and the cornea is called the anterior chamber of the eye; the smaller part that lies between the the iris and the lens is called the posterior chamber. The anterior chamber communicates with the posterior chamber through the central hole in the iris, the pupil, and both chambers are filled with the aqueous humor.

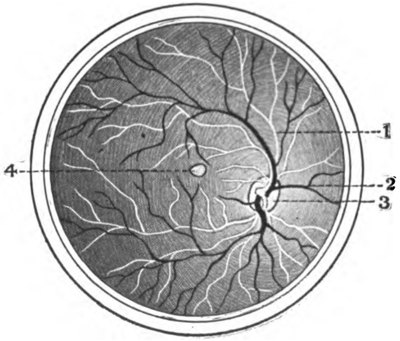
The vitreous humor.—The vitreous humor lies behind the lens and fills the posterior part of the eyeball. It is a transparent, glassy, jelly-like substance, and occupies four-fifths of the eyeball.

The retina.—The retina is a thin, delicate membrane. It forms the inner coat of the eyeball, and extends over the posterior two-thirds only. Its outer surface rests on the choroid and its inner surface on the vitreous humor.

The retina is the part of the eye that gives us the power of vision. All the other parts merely assist the retina in its work. The fibres of the optic nerve are spread out in the retina. Rays of light that enter the eye and fall on the retina have the power to start impulses, which go along the optic nerve to the brain and give rise to sensations of sight.

The region of distinct vision.—Not all parts of the retina are acted on by light in the same way or to the same extent. At the back of the retina, near the centre, is a depression like a saucer. This is called the yellow spot on account of its color. It is the area of most distinct vision. When you wish to see an object distinctly you turn the eyes so as to allow the rays of light coming from the object to fall directly upon the yellow spot.

Rays of light falling upon other parts of the retina give rise to indistinct vision. If you keep your eyes fixed on a word near the middle of a line you can see where the line terminates at either end, and you can see the white margins of the page beyond, but you do not see these things distinctly. By means of indistinct vision, however, we are made aware of the position and movements of objects on either side of us even while our attention is fixed on an object in front of us.



BACK OF RETINA
1. Arteries. 2. Veins. 3. Blind spot.
4. Region of distinct vision

This is a picture of the back part of the retina. Near the centre is the yellow spot where vision is distinct. To the right of this is a round spot with blood tubes branching out in all directions from it. This is where the fibres of the optic nerve enter to be spread out in the substance of the retina. Since

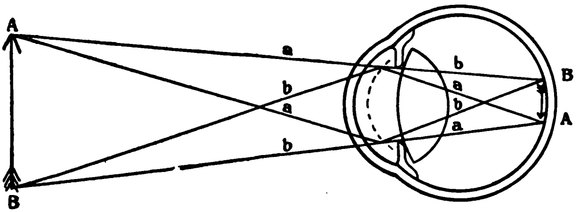
rays of light that fall on this spot do not give rise to vision it is called the blind spot.

To prove that your eyes have a blind spot, look at the star with the right eye while the left eye is closed and the book is

STAR AND CIRCLE

held about a foot from the eye. You will then see the star distinctly and the circle indistinctly. While keeping your gaze fixed steadily on the star, bring the book slowly nearer to the eye. The circle will disappear from view just at the moment when the rays of light from the circle fall on the place where the optic nerve enters the retina; but the circle will reappear when the book is brought still nearer to the eye.

The image on the retina.—In order that we may have distinct vision of any object, an image of the object must be

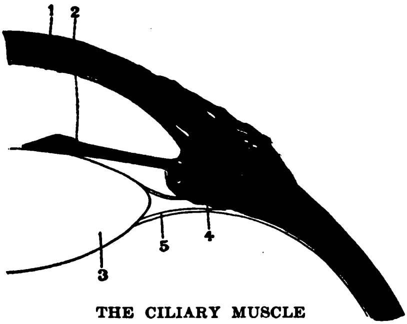


THE FORMING OF AN IMAGE ON THE RETINA

formed on the retina. It is only when this image is clear and well defined that vision is distinct and satisfactory. To obtain a well-defined image, all the rays of light coming

into the eye from any single point must meet at a point on the retina.

In the diagram on page 275 rays of light from the tip A of the arrow diverge, or separate, but they are bent, or refracted, inside the eye by the lens so as to make them meet again at the point A of the image. When the rays meet at the point A they are said to be brought to a focus at that point.



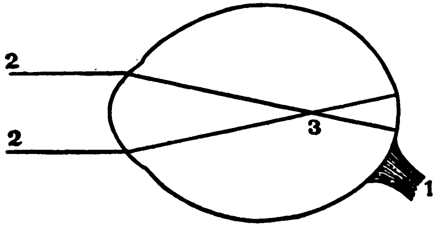
THE CILIARY MUSCLE
1. Cornea. 2. Iris. 3. Lens. 4. Ciliary muscle. 5. Ligament

In a similar way, rays of light from the opposite end B of the arrow meet, or come to a focus on the retina at B.

The whole surface of the arrow on the side toward the eye must be considered as made up of a great number of minute points. Each point sends out diverging rays of light, which are made to converge and come to a focus at a corresponding point between A and B on the retina. An inverted image of the arrow is thus formed on the retina at the back of the eyeball.

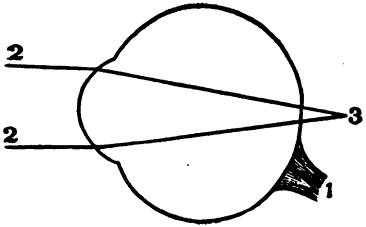
The ciliary muscle.—The ciliary muscle is attached to the inner surface of the outer coat of the eye, at the junction of the sclerotic and the cornea. The fibres of this muscle extend backward a short distance and are fastened to the outer surface of the choroid. When the ciliary muscle contracts, it

draws the choroid forward. This slackens the ligament that connects the choroid with the lens, and allows the front surface of the lens to bulge outward. We are then able to see near objects more distinctly. This change in the lens is called accommodation. When the ciliary muscle relaxes, the choroid returns to its usual position. The ligament then tightens, and pulls on the front surface of the lens, so that this surface becomes somewhat flattened.



MYOPIC EYE
1. Optic nerve. 2. Rays of light. 3. Focus

Accommodation of the eye.—When we look at a distant object, rays of light from it come to a focus on the retina. When we look at a near object, rays of light from it will not come to a focus on the retina until the shape of the lens is changed.



HYPERMETROPIC EYE
1. Optic nerve. 2. Rays of light. 3. Focus

Far sight and near sight.—In the normal eye, rays of light from a distant point come to a focus on the retina. When an eyeball is unusually long from front to back, rays of light from a distant point come to a focus in front of the retina and diverge again. Confused, indistinct vision for distant objects is the result, but near objects

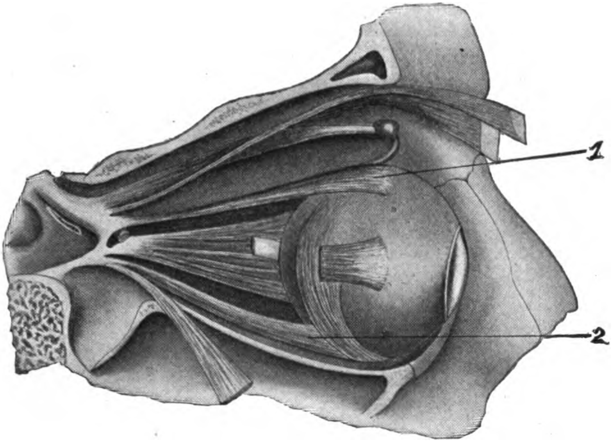
can be seen distinctly. This condition is called myopia, or near-sight. One cause of myopia in children is injury to the ciliary muscle from too much reading or writing, especially in a poor light or a bad position.

On the other hand, when an eyeball is unusually short from front to back, rays of light coming into it reach the retina before they have time to come to a focus. This condition is called hypermetropia, or far-sight. Both these defects may be overcome by wearing suitable eye-glasses. Eye-glasses are lenses made of glass and help the lens of the eye to do work that it cannot do alone.

Color blindness.—Not all persons have the same power to distinguish colors. Those that cannot distinguish between colors, which to most people are quite different, are said to be color blind. Sailors and men employed on railroads and in other places where colored lights are used for signals should have their eyes tested so as to determine their power to distinguish colors.

Movements of the eyeball.—The eyeballs are moved by means of muscles. The picture opposite shows how some of these muscles are attached to the eyeball. They are fastened to the bony wall at the back of the socket and to the eyeball in the front. When, for example, the *superior rectus* muscle contracts, the front part of the eyeball is rotated upward, and when the *inferior rectus* contracts, the front part of the eyeball is rotated downward. These muscles are hidden from view by the membrane that connects the eyelids with the eyeball.

Tears.—Tears are secreted by the tear glands. Under ordinary circumstances just enough fluid is secreted to moisten the surface of the eyeball and the inner surface of the lids, and is carried off by the tear duct which leads into the nose. During



THE MUSCLES OF THE EYE
1. Superior rectus muscle. 2. Inferior rectus muscle

crying or laughing, tears are secreted more rapidly and flow over the edge of the lids upon the cheeks, as well as along the tear ducts into the nose.

Care of the eyes.—The eyes are rested by looking at distant objects, because then the ciliary muscle is relaxed. When we look at near objects for some time the eyes become tired and strained, because the ciliary muscle is contracted. When we are reading we should stop at intervals and rest the eyes by

looking away at something in the distance. This is especially true if the light is poor.

It is important to have a good light when reading, writing, sewing, or when looking constantly at near objects of any kind. It is never safe to read or work in a dim light, or in a flickering, unsteady light. The reading of papers or books in cars often causes serious injury to the eyes. It is very fatiguing to the eye to read when the moving cars keep jarring the body and the printed page.

When we are reading, the light should come from behind and above us. It will then fall upon the page and be reflected to the eye. Light thus enters the eye as much as possible from the page and as little as possible from surrounding objects. The same thing is true of any work we are looking at. We should avoid facing a window, mirror, or other bright surface when we are reading or working. It is trying to the eyes to read out doors, because light enters the eye from every direction. It is also more trying to the eyes to read while lying down than while sitting or standing.

Reading by artificial light is more trying to the eyes than reading by daylight. Large, plain type does not tire or strain the eyes so much as small, indistinct type. It is best to read by daylight such books and papers as are printed with poor type on poor paper, and to reserve the easiest reading for artificial light.

Many pupils form the habit of holding the book too near the eyes. Do not hold the book closer than is necessary.

It is unwise to read much when one is recovering from illness. The eyes share in the general weakness of the body and may easily be overstrained.

When the eyes become tired, or the eyeballs ache or burn, it is time to stop and give them a rest.

When cinders or other foreign bodies enter the eye, they should be removed at once, if possible. Under such circumstances do not rub the eye, but lift the lids and gently wipe away the offending matter with the corner of a clean handkerchief.

SUMMARY

1. Pressure against the skin starts impulses that cause sensations of touch.
2. Some parts of the skin are more sensitive to touch than others.
3. The organs of taste are the tongue and the back part of the mouth.
4. When the nerve endings in these parts are stimulated, impulses are started that cause sensations of taste.
5. When the endings of the olfactory nerve in the lining of the nostrils are stimulated, impulses are started that cause sensations of smell.
6. The ear consists of the external, the middle, and the internal ear.
7. Auditory nerves end in the internal ear. When these endings are stimulated, impulses are started which cause sensations of sound.
8. The outer coat of the eye consists of the cornea in front and the sclerotic at the back. The inner coats are the choroid and the retina.
9. The iris is a thin circular curtain with a central hole, the pupil.
10. The lens lies behind the iris.
11. The aqueous humor fills the part of the eye that is in front of the lens.
12. The vitreous humor fills the part of the eye that is behind the lens.
13. Fibres of the optic nerve are spread out in the retina.

14. Rays of light coming to a focus on the retina start impulses that cause sensations of sight.

15. When the ciliary muscle contracts, the shape of the lens changes so that we may see near objects more distinctly.

16. The eyes are rested by looking at distant objects.

17. In reading, the light should come from above and behind.

18. The book should not be held closer than is necessary.

PART V—DOMESTIC AND PUBLIC HYGIENE

CHAPTER XX

Hygiene explained.—Hygiene is the study of the various means of promoting health and vigor, and of preventing disease. Good health means greater power to work, greater enjoyment in life, and greater freedom from pain. The study of matters that affect the health of the individual is called *personal hygiene.*

There are many matters in the care and management of a home that influence the health of its inmates. The study of such matters is called *domestic hygiene.*

The cleanliness of streets, the purity of drinking water, the safe disposal of sewage, the isolation of persons ill with contagious disease are some of the matters that influence the health of the people in a community. The study of matters that relate to public health is called *public hygiene.*

Matters that relate to personal hygiene have been studied at considerable length in preceding chapters. Inasmuch as domestic and public hygiene have so many matters in common, these subjects will now be studied together.

Disease.—It is not wise to allow the mind to dwell too much on the subject of disease, or to be unduly anxious regarding the probability of contracting an illness. Yet, the healthfulness of an individual, a home, or a community is so important that

every one should learn the simpler facts concerning the causes of disease, and the means of preventing it.

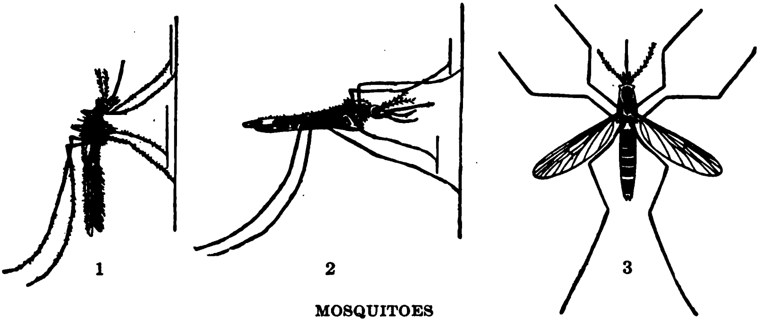
Remarkable advances have been made in recent years in methods of preserving public health. The success already achieved shows clearly that many of our common diseases, such as consumption, typhoid fever, and diphtheria, may be almost, if not entirely, prevented. The chief obstacle in the way of their prevention is ignorance or indifference on the part of the public. There is good reason for hoping that still greater success will result in the future from a wider knowledge of the nature of disease and of the means required for its prevention.

Causes of disease.—There are many causes of disease, but nearly all of them may, for convenience, be divided into two causes. To the first belong those ailments which have their origin within the body. They are due to improper food or clothing, over-eating, want of exercise, drinking of alcoholic liquor, breathing impure air, or similar mistakes in manner of living. All such unhealthful habits and conditions should be avoided.

To the other class belong those ailments that are due to causes without the body. Smallpox, measles, scarlet fever, malaria, and consumption are familiar examples of this class. All such diseases are caused by small animal parasites, or by minute plants called germs, or bacteria.

Animal parasites.—There are a few varieties of animal parasites that enter the body and cause disease. Two of these, trichina and tapeworm, come from eating raw or insufficiently

cooked pork or beef. The parasite of the tapeworm on entering the intestine fastens itself to the wall of the intestine and develops into the mature worm. The worm lives in the intestine where it gives rise to trouble, but is seldom dangerous. The trichina attacks the muscles, gives rise to great pain, and often causes death. The disease usually comes from eating raw or



MOSQUITOES

1. Common mosquito, culex. 2. Mosquito that causes malaria, anopheles. 3. Mosquito that causes yellow fever, stegomyia

slightly cooked ham or sausages, but it may come from uncooked pork of any kind. Thorough cooking, so that every part of the meat reaches the boiling point, destroys the parasites and prevents these diseases.

Malaria, or chills and fever, and yellow fever are caused by minute animal parasites that enter the blood from the bite of mosquitoes. Only one kind of mosquito, the anopheles, can convey the parasite that causes malaria. After the parasite enters the body it remains in the blood, and produces in it many parasites like itself. In a few days there are so many parasites

in the blood that they cause malaria. If an anopheles mosquito bites a man who has these parasites in his blood, it may afterward communicate this disease to another person.

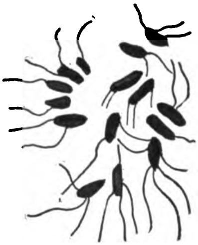
Yellow fever is communicated in a similar way by another kind of mosquito, the stegomyia.

Since the causes of malaria and yellow fever have been understood, successful attempts have been made to prevent the recurrence of these diseases. The best way to prevent them is to avoid being bitten by mosquitoes. Doors and windows should be screened so as to keep mosquitoes out of the house, and if any get in by chance they should be killed.

Every effort should be made to exterminate mosquitoes in the neighborhood. They breed in the water of open rain barrels, stagnant pools, swamps, and marshes. Rain barrels should be kept covered, swamps and marshes should be drained or filled in. If neither can be done, a thin covering of kerosene, known as light fuel oil, should be put on the water of these pools every two or three weeks. Other kinds of mosquitoes cannot cause malaria or yellow fever. But, as others breed in the same places with the harmful kinds, the only safe plan is to exterminate all mosquitoes, for there is no way of separating one kind from another.

Germs.—Germs belong to the lowest order of plant life and consist of a single cell. They are so small that they can be seen only with the aid of a microscope, and for this reason myriads of them may enter the body unperceived. They are very light and float about on particles of dust in the air.

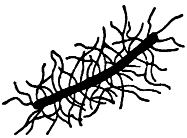
Germs grow in the bodies of those who are ill, then pass out and are conveyed on bedding, clothing, dust, furniture, food, water, or milk, and later infect others. They may enter the body by breathing, eating, drinking, or through the skin.



TYPHOID GERMS
(Magnified)

The only way by which anybody can acquire consumption is by the entry into his body of the germs of this disease. In like manner, the only cause of typhoid fever is the typhoid fever germ; and of diphtheria, the diphtheria germ. But the diphtheria germ cannot cause consumption or any disease except diphtheria. Each contagious disease is caused by its own kind of germ.

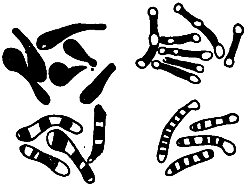
If you put some corn on a bare schoolroom floor you do not expect it to grow. Corn cannot grow without a suitable soil. The germs of disease, like other plants, require a soil that is suited to them in order to grow. Germs find a suitable soil in a body that has become weakened by alcohol, by too little food or sleep, by breathing foul air, living in dark rooms, lack of exercise, and similar causes. As a result, the body is run down, and in its weakened condition germs find a soil in which to grow.



ONE MORE HIGHLY MAGNIFIED

But when the body is in vigorous health, the germs that enter it do little or no harm, because they seldom find in a vigorous, healthy body a soil suited to their growth. It is probable that

few persons reach manhood or womanhood without, at some time, inhaling the germs of consumption. Yet there are many persons who do not contract this disease, for the conditions in their bodies are such that the germs die, and so become harmless.



DIPHTHERIA GERMS
(Magnified)

This natural resisting power of the body is its greatest protection against the invasion of harmful germs. While we do not know all about this power to resist or destroy germs, yet we know that it is greatest when we are in good health.

How germs may be destroyed.—Substances which destroy germs are called disinfectants. All true disinfectants are germ-killers. Other substances which merely arrest or retard the growth of germs are called antiseptics.

CONSUMPTION GERMS
(Magnified)

Burning in a room brown paper, or coffee, sprinkling ammonia, perfume, or other strong-smelling liquid, may hide disagreeable odors, but such means will not destroy germs or other causes of disease. They merely substitute one odor for another, and are called deodorants.

Disinfectants.—There are many ways of destroying germs, but no one way is suitable for all cases. Fresh air, continuous cleanliness, and freedom from dust assist very greatly in disinfecting a sick-room. One of the best aids is the use of soap and hot water on the floor and furniture.

Boiling water destroys germs of all kinds. This is an easy way of disinfecting many articles of clothing and bedding. Sunlight and fresh air are nature's means of disinfecting. The decay and filth in damp, dark cellars are quickly destroyed when brought out to fresh air and light.

Lime is a cheap and useful disinfectant in cases where it can be used. Lumps of quicklime are first slaked by adding to them about one-third of their weight of water. This makes a powder, or a creamy fluid. One quart of this put into three quarts of water makes a good solution. A coating of limewash is useful on the walls of cellars, stables, and outhouses. Chloride of lime, when mixed with water so as to make a thin solution, is a good disinfectant, especially to destroy germs in the excreta, *i. e.*, discharges from the bowels and kidneys of persons who are ill with infectious diseases.

Camphenol is a disinfectant that may be used in a great variety of ways. It destroys germs, but does not injure clothing or furniture.

For fumigating rooms, the vapor of formaldehyde is a rapid and powerful disinfectant and deodorant.

Isolation.—The object of isolation is to prevent the spread of contagious disease from one person, house, or locality to

another. The best way is to separate those who are ill with contagious disease from all other persons except necessary attendants. People should be prevented from entering an infected house until all danger of communicating the disease is past. The time during which isolation should be continued varies with the severity of the attack and with the kind of illness.

It is very necessary that all cases of contagious disease, even the mildest, should be isolated. No one on account of inconvenience, pecuniary loss, or any other reason should seek to evade isolation. Humane, conscientious people are willing, when they have contagious disease in their homes, to take a great deal of trouble to prevent the spread of such disease to others.

COMMON CONTAGIOUS DISEASES

Diphtheria.—Diphtheria occurs most frequently in children, but it often attacks grown people. It is contagious and is caused by germs which pass from persons who are ill with the disease to others.

It is not caused by sore throat. A case of ordinary sore throat cannot develop into diphtheria unless the germs are present. The germs are in the mucus that is coughed up, and in all the discharges from the nose and throat. They are often present in the saliva that escapes from the mouth while sleeping. One attack of diphtheria does not make a person less liable to a second attack.

The severity of this disease varies greatly with different individuals. It is often so mild that it is overlooked, being mis-

taken for a trifling sore throat. It is sometimes so severe that the patient's life is in danger in a few hours after the attack begins. The germs in the mildest case are infectious, and may give rise to the disease in its severest form.

The mild cases are the ones that cause the disease to spread because they are so often overlooked or neglected. Diphtheria is frequently spread through schools. The pupils sit near one another and often exchange their garments and their toys. Children should be warned against exchanging their whistles, mouth-organs, strings, candy, gum, half-eaten apples, and, in fact, everything that goes into the mouth. They should be warned also against chewing the ends of their pencils and penholders, and should be taught not to put anything into the mouth except food and drink.

The best means for preventing the spread of diphtheria are isolation of all cases, the mildest as well as the more severe; immediate destruction by burning, or by some other way, of all discharges from the nose and throat; and thorough disinfection of all clothing used by the patient, and also of the premises after the attack is over.

Scarlet fever.—Scarlet fever is the most serious of all the infectious diseases of childhood. It is very contagious. It commonly attacks children, but it may attack adults.

It is caused by something called a contagium, which is probably a germ, and is transferred, in some way, from those who are ill with the disease to others. This contagium is contained in the discharges from the throat and nose, in the scales during

peeling of the skin, and also in excreta from the bowels and kidneys.

The contagium may be conveyed on clothing, books, food, or on anything touched by the sick while peeling of the skin is taking place. It clings for a long time to clothing, bedding, furniture, dishes, and may be carried long distances by persons, letters, towels, and pet animals, such as cats and dogs, that are allowed to come into the sick-room. It may be transferred from the sick to the well throughout the entire duration of the disease, from the very first symptom to the disappearance of the very last.

Complete isolation of those ill with the disease, and thorough disinfection, both during the disease and afterward, are the surest ways of preventing the spread of scarlet fever.

Measles.—Measles is one of the milder diseases of children, but it is very contagious. It is caused by something, probably a germ, that passes from one who is ill with the disease to those who are well. It is not caused by a cold or a sore throat, but always by a previous case of measles.

It is scarcely ever taken more than once; the first attack, as a rule, protects the body against another. Because of this, ignorant persons sometimes advise exposing a well child to measles with the idea that he is sure to have it sometime, and it is better to have it over at once.

No one should ever advocate exposing a child to any disease. Exposing a child to measles or to any disease is very wrong and cannot be too severely censured, because every case is a centre

of danger from which the disease is liable to spread to others, and because very many delicate children between two and five years of age die of measles.

On account of its mildness, the opinion prevails that strict quarantine is not necessary in measles. Yet very few diseases are so easily communicated from the sick to the well. The contagium is carried in clothing, by currents of air, by pet animals, and sometimes over long distances by letters.

Strict isolation of all cases, and thorough disinfection, both during the disease and afterward, are necessary to prevent the spreading of measles.

Whooping cough.—Whooping cough is a contagious disease. It may affect adults, but it is usually seen in children. As a rule, it occurs but once in the same person.

The contagium of whooping cough is transferred from those who are ill to those who are well. It does not develop from a cold, or from anything but a previous case.

Children that have whooping cough should not be allowed to attend school, church, or any public gathering, and should be kept from other children.

Infants and delicate children should be carefully protected from exposure, because they are the ones in whom the disease is most liable to prove serious.

The discharges from the throat, nose, and mouth of one who is ill with whooping cough are liable to communicate the disease to others. These discharges should be received in vessels containing a strong disinfectant, or on soft rags which should

be burned immediately. After recovery, there should be careful disinfection of the room and clothing.

Small-pox.—Small-pox is a contagious disease. Before the discovery of vaccination small-pox was the most virulent and fatal of all maladies known to mankind. During the early stages the eruption on the skin resembles the rash in chicken-pox.

Whenever small-pox appears in a household or in a neighborhood, every one should be vaccinated without delay. Isolation of those who are ill, disinfection, and successful vaccination are the best means of preventing the spread of small-pox.

Typhoid fever.—Typhoid fever is an infectious disease. Persons of all ages are liable to take it. It is caused by germs that come from a previous case of typhoid fever, and there is no other cause of the disease.

The germs seldom pass directly from the one who is ill to those who are well, but they may do so. By far the most common mode of conveying the typhoid fever germ is by means of drinking water. These germs may get into wells, reservoirs, springs, rivers, or lakes, and cause epidemic outbreaks among those who drink the water.

One epidemic in a town in Pennsylvania was caused by a single case of typhoid fever that occurred in a cottage on a hill. The hill sloped toward a stream that supplied the town with drinking water. The patient was ill during January, February, and March. The ground was frozen and covered with snow, and on this were thrown the discharges of the bowels and kidneys

of the patient. During the latter part of March and early April there was a thaw and a heavy rain that washed these discharges into the stream about sixty feet away. In a short time an epidemic of typhoid fever broke out in the town, and of the eight thousand inhabitants about twelve hundred took the fever, and one hundred thirty died of it.

Milk may convey the germs of typhoid fever if the cans that contain milk are washed with water containing germs. The germs grow very rapidly in fresh milk. The germs may be conveyed in ice if it is taken from ponds or streams that are contaminated. Oysters, also, that are fattened in contaminated water may convey the disease.

In some epidemics it has been shown that flies were the carriers of the infection. In these cases the excreta of a typhoid fever patient were not disinfected, but were thrown out on the surface of the soil. Flies then conveyed the germs on their bodies to milk and other food that was left uncovered. At all times flies should, so far as possible, be kept out of the house. Doors and windows should be provided with screens, and all food should be kept covered so that flies may not convey to it infection of any kind.

The germs of typhoid fever leave the body along with the discharges from the bowels and the kidneys. All excreta from a typhoid fever patient should be carefully disinfected according to the directions of the physician or the medical health officer of the district. All clothing and bedding and other articles used by the patient should be disinfected.

Boiling kills the germs of typhoid fever. Whenever there is the least suspicion that drinking water contains the germs it should be boiled for a few minutes.

Consumption.—It is said that more people die from consumption than from any other disease. It is a disease that spreads from one person to another, and any one may catch it.

Consumption is caused by a germ, the tubercle bacillus, which is contained in what is coughed and spit up by one who is ill with the disease. If this sputum is allowed to dry, the germs mix with the dust, float in the air, and settle on walls, carpets, and furniture. They are then breathed in by others and settle in the throat and lungs, causing consumption of these parts.

Consumption or, as it is often called, tuberculosis of the lungs is a disease that can be stopped and, therefore, it need not spread. The chief means of stopping it is to take care of the sputum. It should be kept moist until it can be disinfected or disposed of. If the sputum of all persons ill with consumption were destroyed as soon as it leaves the body, practically the only danger of communicating the disease from one person to another would be removed.

If your body is in good health it can resist these germs so that they will not cause consumption; but if your body is weak, it may not be able to resist them.

The body may become weakened by alcoholic drinks which are among the greatest helpers the germs have, by any form of dissipation, by too little food, air, and light, by any severe illness, or often by a simple cold.

The best ways for keeping the body strong are to be in the open air as much as possible, to drink plenty of pure water, eat plain, wholesome food, keep early hours, sleep eight hours a day, and live as regular a life as possible. You should consult a doctor when you have a persistent cough, are run down, or cannot stand as much work as you could formerly.

Extract from a Circular issued by the Department of Health, City of New York:

"Consumption is a disease of the lungs, which is taken from others, and is not simply caused by colds, although a cold may make it easier to take the disease. It is caused by very minute germs, which usually enter the body with the air breathed. The matter that consumptives cough or spit up contains these germs in great numbers—frequently millions are discharged in a single day. This matter, spit upon the floor, wall, or elsewhere, dries, and is apt to become powdered and float in the air as dust. The dust contains the germs, and thus they enter the body with the air breathed. This dust is especially likely to be dangerous within doors. The breath of a consumptive does not contain the germs and will not produce the disease. A person catches the disease from a consumptive only by in some way taking in the matter coughed up by the consumptive.

"Consumption can often be cured if its nature be recognized early and if proper means be taken for its treatment. In a majority of cases it is not a fatal disease.

"It is not dangerous to live with a consumptive, if the matter

coughed up by him be promptly destroyed. This matter should not be spit upon the floor, carpet, stove, wall, or sidewalk, but always, if possible, in a cup kept for that purpose. The cup should contain water so that the matter will not dry, or, better, carbolic acid in a five per cent. watery solution (six teaspoonfuls in a pint of water). This solution kills the germs. The cup should be emptied into the water-closet at least twice a day and carefully washed with boiling water.

"Great care should be taken by consumptives to prevent their hands, face, and clothing from becoming soiled with the matter coughed up. If they do become thus soiled, they should be at once washed with soap and hot water. Men with consumption should wear no beards at all, or only closely-cut moustaches. When consumptives are away from home, the matter coughed up should be received in a pocket-flask made for this purpose. If cloths must be used, they should be immediately burned on returning home. If handkerchiefs be used (worthless cloths which can be at once burned are far better) they should be boiled at least half an hour in water by themselves before being washed. When coughing or sneezing small particles of spittle containing germs are expelled, so that consumptives should always hold a handkerchief or cloth before the mouth during these acts.

"A consumptive should have his own bed, and, if possible, his own room. The room should always have an abundance of fresh air—the window should be open day and night. The patient's soiled wash-cloths and bed-linen should be handled

as little as possible when dry, but should be placed in water until ready for washing.

"If the matter coughed up be rendered harmless, a consumptive may frequently not only do his usual work without giving the disease to others, but may also thus improve his own condition and increase his chances of getting well.

"Whenever a person is thought to be suffering from consumption the Department of Health should be notified, and a medical inspector will call and examine the person to see if he has consumption, providing he has no physician, and then, if necessary, will give proper directions as to treatment.

"Rooms which have been occupied by consumptives should be thoroughly cleaned, scrubbed, whitewashed, and painted, or papered before they are again occupied. Carpets, rugs, bedding, etc., from rooms which have been occupied by consumptives, should be disinfected."

Tetanus, or lockjaw.—Tetanus is caused by the infection of a wound with the tetanus germ. This germ is often present in garden soil, and in all kinds of earthy matter, in the dust of streets and houses, and on splinters of flooring or on rusty nails.

The disease frequently occurs because of wounds made accidentally by firing blank cartridges, toy cannon, and firecrackers. The germs are usually not contained in these articles, but are in the dirt on the hands, or other part of the body, at the time of injury. This dirt is carried deeply into the lacerated flesh where the germs may find the conditions favorable for their growth.

All wounds, and especially those contaminated with earth or dust of any kind, should be carefully washed and disinfected. Blank cartridge and firecracker wounds should be regarded as dangerous. They should receive prompt and careful surgical treatment.

Cleanliness.—The healthfulness of any city, town, or district is greatly influenced by the cleanliness of its streets, yards and houses; by the purity of the drinking water supplied to its inhabitants; and by complete isolation and disinfection in all cases of contagious disease.

Purity of drinking water.—One of the most important duties of the officials of a town or city is to provide an abundant supply of pure drinking water.

Fresh water comes from the aqueous vapor of the atmosphere and falls to the earth in the form of rain or snow. Some of it flows away on the surface into streams or lakes, another part sinks into the earth, percolates through the soil, and furnishes the water which we obtain from springs and wells.

Wells and springs near dwellings in villages and in rural districts often contain impurities. In many places great carelessness is shown in regard to the position and management of wells. They are often located with only one object in view—that of convenience. In choosing a site it should always be remembered that wells drain a large area. The water on its way to the well percolates through the surrounding soil for a considerable distance, and is very liable to convey impurities if the soil is contaminated. Often there is not sufficient care taken

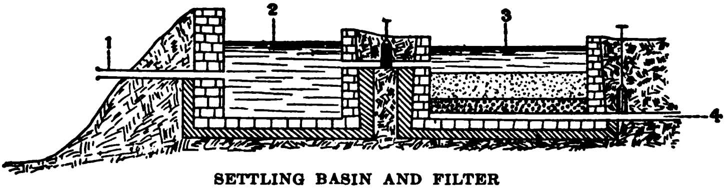
to prevent domestic animals from polluting wells, the ground around them being a favorite resort for cattle and poultry. The contamination of wells is a common cause of typhoid fever.

In villages and rural districts the surface around wells should be higher than the surface farther away, so that water falling on the ground may drain away from the well and not toward it. Wells should be located as far as possible from stables, farmyards, outhouses, and cesspools, in order to avoid polluting the drinking water.

Rivers, streams, and lakes that are situated in thickly inhabited districts are very liable to pollution. Such water is made impure by the waste and surface water of stables and farmyards, by all kinds of refuse from dwellings, and by the sewage of towns on their banks. The greatest danger from contamination by sewage and household refuse is that it may at any time add to the water the germs of typhoid fever or other infectious disease. Extreme care should be taken to guard the sources of supply in order to keep drinking water pure and prevent contamination.

Filters.—In many large cities, sand filters are used for purifying water. At the top of the filter there is a layer of fine sand varying in thickness from one foot to three or four feet. Below the sand is a layer of gravel, which varies from a foot to two feet in thickness. Drain pipes are placed under the gravel. The water to be purified enters the filter at the top, soaks slowly down through the sand and gravel, passes into the drain pipes below, and is carried off ready for use.

Such a filter purifies water in two ways. The sand in the filter acts as a strainer and removes from the water solid impurities and large numbers of harmful bacteria. In addition to harmful bacteria, such as those that cause typhoid fever, there are vast numbers of bacteria that are helpful. On the



SETTLING BASIN AND FILTER

1. Inlet. 2. Settling basin. 3. Filter. 4. Outlet

grains of sand near the top of a filter are myriads of helpful bacteria. These aid very much in purifying water by destroying harmful bacteria.

If water contains a large amount of sediment, it is usual to let the water pass first into a settling basin, where the sediment, in a few hours, settles to the bottom. If it were allowed to enter the filter, the sediment would fill up the minute spaces between the grains of sand, choke the filter, and so prevent the water from soaking through.

Removal of refuse.—Refuse from dwellings consists of ashes; garbage, consisting of scraps of food, peelings, and other kitchen waste; sewage, which includes excreta, and waste water from wash-tubs, bath-tubs, sinks, laundries, and rain water from the roofs of houses.

Ashes should not be allowed to accumulate in cellars, or in

heaps in back yards, but should be frequently and regularly removed from the premises.

Garbage quickly decays, and, if allowed to remain near the house, may pollute both the soil and the air. In many cities and towns the garbage is collected regularly and burned. This is a satisfactory way of disposing of it.

Sewage.—The prompt and safe removal of sewage is a very important problem. In cities and in many towns it is carried away by means of water in underground pipes called sewers. All dwellings and premises are connected with a sewer by smaller pipes called drains. Drains and sewers should be carefully constructed and securely fastened together to prevent leakage. They should also be ventilated so that gases, which tend to collect in sewers, may escape into the atmosphere. It is also very important that in houses all connections of drain pipes with baths, sinks, and closets, should be absolutely air-tight, and arranged so that no gases can escape into a dwelling from the drains and sewers.

The ultimate disposal of sewage, after it has passed along sewers to their outlet, is an exceedingly important matter that sometimes fails to receive the attention that it deserves. If sewage is allowed to flow into a river and the water of the river is afterward used for drinking, there is always great danger of typhoid fever. In the disposal of sewage some plan should be adopted by which contamination of soil and drinking water may be avoided.

Cleanliness of streets, yards, and houses.—Every thrifty housewife dislikes dust, for she regards its presence in a house as a sign of poor housekeeping. One problem of good housekeeping is to eliminate dust as completely and easily as possible. There is a tendency among good housekeepers to "banish the broom." In sweeping a floor with an ordinary house broom, much dust is stirred up only to settle again on the floor and all articles of furniture. Where floors are made of some smooth, hard material, and are wiped frequently with a damp cloth, dust is removed more completely, and is not scattered about. This, of course, cannot be done where carpets are used. In many cases small rugs are better than carpets, for rugs can be taken up frequently and cleaned out of doors. In cleaning schoolrooms, the floors and desks should be wiped with a damp cloth every day.

When carpets and heavy furnishings are used, some kind of vacuum process for cleaning is desirable. By this method no dust escapes to settle down again, but it is collected and removed. This process should be used, in preference to sweeping, in cleaning public buildings, such as hotels, clubs, office buildings, churches, theatres, and large business establishments.

All yards and premises should be kept free from rubbish and useless material of all kinds. It would be much better if yards in the rear of houses were kept as tidy and neat as yards in the front are usually kept.

The healthfulness of all cities is influenced by the condition of the streets. It is desirable that streets be paved, for it is

difficult to keep unpaved streets clean, especially where there is much traffic. Asphalt is the most sanitary paving, because it is smooth and impermeable, and may be more easily cleaned than any other kind.

APPENDIX

EXPERIMENTS

A FEW simple experiments with suitable specimens are a great aid in teaching physiology. A clearer idea is obtained by examining a specimen than by reading many pages of descriptive matter.

A number of good specimens may be obtained without difficulty. These should be carefully prepared before they are brought into the class room. All blood stains and superfluous tissue, such as fat, should be removed so as to have the specimens as neat and attractive as possible. After they are made ready they should be kept in a damp cotton cloth till they are used.

All that is necessary besides specimens is a sharp knife, a pair of scissors, a few large plates, and a supply of towels. It will sometimes be necessary for the teacher to procure two specimens, and to examine one thoroughly before attempting to give a lesson with the other in the class room.

BONES

Structure.—Ask a butcher to prepare the shin-bone of a sheep or calf by sawing it across the middle, and by sawing one of the pieces in two lengthwise. Note the central cavity of the shaft, and the ring of solid bone around it. Compare the

shaft with the end of the bone, and observe their difference in structure.

Periosteum.—Get a fresh bone and remove all pieces of muscle and tendon. Cut across the bone with a sharp knife in two places an inch or two apart. Then cut lengthwise from one cut to the other and peel off the thin periosteum with the point of a knife. Notice how firmly this membrane is attached to the bone.

Compare an old dry bone with a fresh one, and notice their different appearance. Small holes may be seen in the surface of a dried bone showing where little arteries from the periosteum entered to carry blood for the nourishment of the bone.

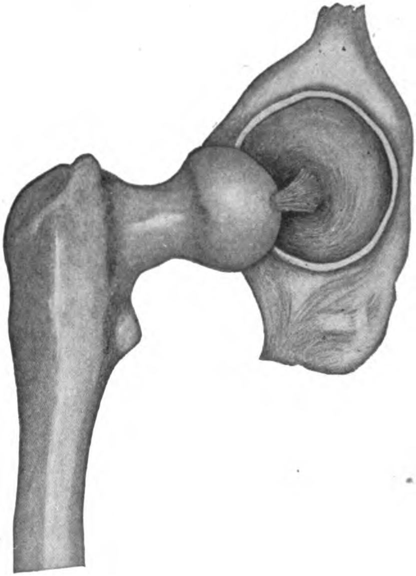
The animal and the mineral part.—To show the animal and the mineral part of bone, see the chapter on bones.

Marrow.—Saw a fresh long bone across and take out marrow with a small spoon. It is composed largely of fat and blood tubes.

Bones of spine.—Get the neck of a sheep and boil it for two or three hours. Clean off the muscles and ligaments, and place the bones in their natural position. You can easily see how they fit together, and how the hole in the centre of the bones of the spine forms a canal for the spinal cord.

Joints.—Get a fresh knee-joint from the foreleg of a sheep. Have it cut off about three inches above and three inches below the joint. This is an example of a hinge-joint. Hinge-joints open and close like a hinge of a door. The joints of the finger, the elbow, and the knee are examples of hinge-joints.

Cut the joint open and observe the firm, tough ligaments which form the side walls of the joint. Notice and collect the joint oil, or synovia. Notice, also, the synovial membranes which line the inner surface of the ligaments and secrete the joint oil.


BALL AND SOCKET OF HIP-JOINT

Feel the smooth surface of the cartilage that covers the ends of the bones.

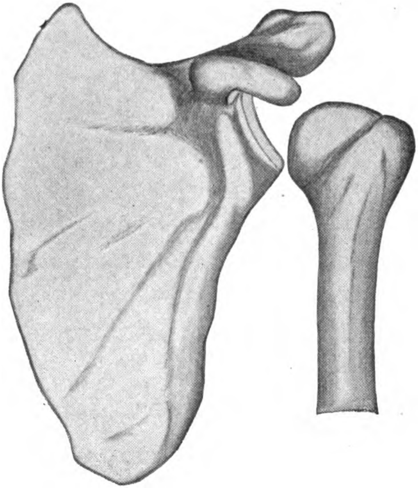
The hip-joint of a leg of lamb, of a chicken, or of a turkey will furnish an example of ball and socket-joint. Observe the ball and the socket into which the ball fits, and also how freely the ball can move in all directions in the socket. Our hip-joints and shoulder-joints are ball and socket-joints. Notice how much more freely these joints move than our own knee and elbow-joints.

After the lamb, chicken, or turkey is roasted the bones will not have the appearance of fresh bones. A fresh ball and socket-joint may be obtained from your butcher by asking him for the bone he takes out of a fresh ham when he prepares it in that way for roasting.

MUSCLE

Fresh lean meat of any kind will illustrate the appearance of muscle.

The position and shape of some of the muscles in the lower part of the leg of a chicken or turkey may be easily seen. Cut off the lower part of the leg before it is cooked. Remove the skin and carefully separate the muscles. Observe the thin sheets of connective tissue that bind the muscles together. Notice, also, how the muscles are attached to the tendons. Pull the tendons to show how the toes are moved. Dissect out one of the tendons as far as its attachment to the bone.



BALL AND SOCKET OF SHOULDER-JOINT

Observe the tendons on the back of your hand when you open and close your hand.

Grasp your arm between the shoulder and the elbow, then bend the arm at the elbow. You will feel the biceps muscle swell up in the middle as it contracts, and become smaller as it relaxes.

The structure of muscle may be shown with corned beef.

Boil a piece of lean corned beef and you will be able to separate the fibres of which the muscle is composed, because boiling softens the connective tissue that holds the fibres together.

FOOD

Samples of the various kinds of food may be used to illustrate the classification of foods. Such of them as can be kept should be put into small glass bottles and preserved for future use.

Proteids.—Among the more common proteids are albumen, myosin, gluten, and casein.

Albumen and myosin.—White of egg is pure albumen. Lean meat consists largely of myosin. Scrape a piece of lean raw beef. The part that is scraped off consists chiefly of myosin. The shreds that remain consist of connective tissue. These may be changed into gelatine by boiling. Heat hardens, or coagulates, albumen and myosin. Every one is familiar with the difference between the white of egg before it is cooked and after it is cooked. Drop a little raw white of egg into hot water.

Gluten.—Gluten is a product of wheat. Starch and gluten make up the greater part of wheat flour. Put a spoonful of flour into one cup and a spoonful of corn-starch into another. Add a little water to each. Stir and note the difference between them. This difference is due to the gluten in the wheat flour.

Put a little wheat flour into a small muslin bag and knead it well in a basin of water. Note the milky appearance of the water when the bag is squeezed. If this water is allowed to

stand, the starch in it will settle to the bottom in the form of a white powder. Turn the bag inside out and notice the sticky yellowish gluten adhering to the muslin.

Casein.—Casein may be obtained from milk. Take one half pint of fresh milk and heat it till it is lukewarm. Add one teaspoonful of Fairchild's essence of pepsin, and stir just enough to mix. Let it stand until a firm curd of casein is formed. If the curd is broken up and strained, a liquid called whey is obtained.

Carbohydrates.—The chief carbohydrates are starch and sugar. Flour, rice, potatoes, corn-meal, sago, and tapioca are common starch foods.

The best test for starch is iodine. Get an ounce of the tincture of iodine at a drug store. A drop put on a little boiled starch gives a very dark-blue color, which becomes a beautiful light blue when water is added. If any food consisting largely of starch is boiled, and a drop of the tincture of iodine is added, the blue color that shows the presence of starch may be obtained. (For details of experiments, see *Physiology and Hygiene for Children*, page 184.)

Cut two or three potatoes into thin slices, cover with water, and stir the slices about for a few minutes. The water will become milky, and, if it is allowed to stand, the starch in it will settle to the bottom as a white powder. The powder may be obtained by pouring off the water. If the powder is cooked, and tested with iodine, the blue color that shows starch may be obtained.

Samples of cane, beet, milk, grape, and maple sugar may be obtained for examination. (To test for sugar in milk, see *Physiology and Hygiene for Children*, page 186.)

Fats.—Show samples of fats. Butter, tallow, and lard are obtained from animals. Sweet oil and cotton-seed oil are obtained from vegetables. Vaseline is a mineral oil.

Salts.—Procure from a drug store samples of a few of the more common salts that are found in food, such as calcium phosphate, calcium carbonate, sodium phosphate, sodium carbonate, sodium bicarbonate, potassium chloride, and ferric oxide. Compare these with sodium chloride, common salt. Samples of these should be kept in small bottles for comparison. Pupils will, in this way, become familiar with the use of the word salt in its larger meaning.

DIGESTION

The teeth.—Procure from a dentist specimens of the different kinds of teeth. Observe the root, crown, neck, and the enamel covering of the crown. Break a tooth with a hammer and observe the pulp cavity and the channels in the roots for nerves. Obtain a decayed tooth and break it so as to show how the nerve was exposed in the cavity.

Examine the mouth of a chicken or turkey and note the absence of teeth. Examine the gizzard to see how it takes the place of teeth. Observe its thick muscles and the tough covering of its inner surfaces which fit it for grinding food. Notice also any little pebbles that it may contain to aid it in this work.

The saliva.—To show that saliva changes starch to sugar, see *Physiology and Hygiene for Children*, p. 187.

The stomach.—Obtain from a butcher a small piece of the wall of a pig's stomach. With the aid of a magnifying glass find the openings of the glands that secrete the gastric juice.

The liver and the pancreas.—A specimen of each from a pig or a sheep may be easily shown.

Pancreatic digestion of milk.—This experiment illustrates the action of the pancreas ferment, trypsin, in digesting the casein of milk in an alkaline medium.

Into a quart saucepan put three ounces of water, twelve ounces of fresh milk, and fifteen grains of bicarbonate of soda. Heat on a gas stove, or in any way that is convenient, to about 140° F., then divide into two goblets or large tumblers. To one of these goblets add ten grains of Fairchild's extractum pancreatis, stirring in well, and allow the milk to stand, with frequent stirring, for about twenty minutes.

To show that the casein has been quite thoroughly digested, *i. e.*, changed into peptone, as digested proteid is called, add two drachms of acid, either dilute muriatic or acetic, C.P. (the latter is generally used). It will then be seen that the milk remains fluid, as acids will not precipitate peptone.

Now, for purposes of comparison, add the same quantity of acid to the glass containing the other half of the warm milk mixture which has been simply allowed to stand, and stir it up slowly from the bottom of the glass. In a few minutes the casein will be all gathered into a lump, a hard cheesy mass,

showing that the water and soda have no influence in preventing coagulation. This illustrates very effectively the value of peptonized milk in feeding the sick.

Pancreatic digestion of starchy foods.—The action of the pancreas ferment, amylopsin, may be illustrated in the following way: Dissolve one tablespoonful of Taylor Bros.' Bermuda arrowroot in one pint of cold water. Heat with constant stirring until it comes to a boil, when it will be a perfectly clear, smooth starch mucilage. When this mucilage has cooled down to about 130° F. pour into a tall tumbler, and sprinkle over this ten or fifteen grains of Fairchild's extractum pancreatis, and begin to stir with a spatula. The starch on the top will begin to liquefy almost immediately, and as the mucilage is stirred deeper, it will all liquefy and become as fluid as water. This liquefied starch can be poured from glass to glass as if it were water, and the change is thus illustrated very prettily.

To show the action of pepsin on albumen in an acid medium.—Take the whites of two fresh eggs, carefully separated from the yolks; add eight ounces of cold water; mix thoroughly; heat with constant stirring to the boiling point, and boil with constant stirring for at least five minutes, being careful not to scorch. Strain through cheese-cloth, without too much pressure, so as not to squeeze through any of the hard particles; set aside until cold.

Pour this gelatinized albumen into a glass and add forty minims of hydrochloric acid, C.P., and shake well. Put four drachms of this acidulated albumen into a test-tube, add two or

three grains of Fairchild's scale pepsin; let it stand in a glass of warm water, temperature about 130° F. In a few minutes the albumen will begin to dissolve. The progressive action of the pepsin may be noted by showing the test-tube from time to time.

For comparison, have another test-tube with the same amount of albumen mixture, under the same conditions, without the pepsin. The contents of one tube will become clear as water, the contents of the other will remain opaque like starch jelly.

To show the action of the emulsive ferment of pancreatic juice.—The characteristic action of the emulsive ferment is the conversion of oils or fats into a state of minute division, or emulsion.

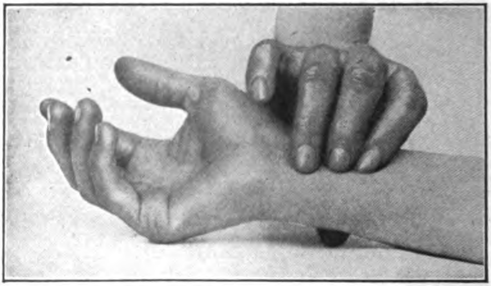
To show this action of the emulsive ferment add a few grains of Fairchild's extractum pancreatis to one or two drachms of warm water and one ounce of cod-liver oil, or pure olive oil. Shake well and let the mixture stand in a warm place for five or six hours. At the end of this time it will be found the oil will form a creamy emulsion, if an equal amount of water is added and the mixture is well shaken. On standing, this emulsion will gradually separate, but may be again emulsified by shaking.

CIRCULATION

The pulse.—Feel with the fingers for the pulse at the wrist. It is best found at a short distance from the base of the thumb, and just a little to the outer side of the tendons. Count the

number of beats per minute after you have been quiet for a time. Then count the number of beats per minute after a few minutes of violent exercise.

Blood.—Get two jelly jars and fill them with fresh blood—or get your butcher to do it. Put a tablespoonful of Epsom salts into one while the blood is fresh, and let both stand. The



FEELING THE PULSE

blood containing Epsom salts will not clot, but will remain unchanged. The blood in the other jar will clot. Examine the clot and the serum.

If possible, examine a drop of blood under a microscope.

Heart.—Get a sheep's heart from a butcher. Ask him for one with the sac still surrounding it, and request him to retain the large artery and the veins for two or three inches above the heart.

Cut open the pericardium, the sac which surrounds the heart, and notice its smooth, slippery lining. This prevents friction between the sides of the heart and the surrounding organs.

Find the groove of the heart. You can recognize it by the layer of fat which lies upon it. The groove marks the position of the septum which divides the right side from the left side. Hold the heart so that the groove will be up and the apex will point away from you. The part to your right is the right side of the heart, and the part to your left is the left side of the heart. Squeeze the heart on both sides of the groove with thumb and fingers, and notice the thin wall of the right side and the thicker wall of the left side.

Now hold the heart so that the apex will point downward. Cut down through the right auricle on its outer side. Examine its interior, and pass the finger down through the opening into the ventricle below. Continue the cut down through the wall of the right ventricle. Examine the valve between the auricle and the ventricle. Pass the finger up under the thin flaps. Notice the strings attached to the edge of the flaps and to the wall of the ventricle. Find the openings by which the blood enters the auricle from the veins, and the opening by which it leaves the ventricle.

Follow the opening into the pulmonary artery until the artery divides into a branch for each lung. Cut through the wall of this artery and examine the valves that are placed at the beginning of the artery.

In a similar way open and examine the left auricle and the left ventricle. Notice their valves, and compare the thickness of the wall of the left ventricle with the wall of the right ventricle. Notice that the septum forms a complete partition between the

right and the left side. Follow up the opening from the left ventricle into the aorta, and examine the aorta and its valves.

THE LUNGS

Secure the heart and lungs of a sheep with the windpipe attached. Wash away all traces of blood and remove fat and connective tissue. A fresh lung has a beautiful pink color, owing to the presence of blood in its capillaries. Note their external appearance, the arrangement and number of lobes on each side. Feel the lungs and observe the spongy nature of the lung tissue.

Examine the windpipe and its rings of cartilage. Insert the nozzle of a bicycle pump into the windpipe and inflate the lungs. Scrape away portions of lung tissue from the large bronchial tubes, and follow one of these tubes. Observe the divisions of the bronchial tube, and also the blood tubes that lie beside them.

Trace the large blood tube that enters the lung back to the heart, and notice which part of the heart it starts from.

Cut off a small part of the lung substance and observe how it floats in water. Why does it float?

With a tape line measure the chest of a pupil, on the outside of the clothing. Note the size after a full inspiration, and again after a full expiration, to show that the chest increases in size during inspiration.

Count the number of respirations in a minute when a pupil does not know you are counting. The number averages from sixteen to twenty.

Expired air contains considerable water in the form of vapor. To show this, breathe on a mirror, or on any highly polished metal.

Expired air contains also carbon dioxide. To show this, obtain a little lime-water at a drug store. Breathe out through a straw, or a glass tube, into a glass of lime-water. The lime-water soon becomes milky in appearance because the carbon dioxide unites with the lime in the water to form carbonate of lime.

THE BRAIN

Procure the brain of a sheep and the membranes surrounding it, in their natural position. Ask the butcher to be careful in sawing the skull and in taking out the brain so that it may not be injured.

Remove the membranes, and explain that they protect the brain, and contain blood tubes which convey blood to nourish the brain.

Notice the deep fissure which divides the brain into two equal parts. Observe the wrinkled surface of the brain, and pass a pencil along the hollows to show their depth.

Cut off a part of the brain to show the position of the gray matter and of the white matter.

Look for some of the cranial nerves on the under surface of the brain.

Show how the brain extends downward into the spine as the spinal cord.

Procure from a butcher three or four inches of the spinal cord of an ox to show what it is like.

How to examine the eye of an ox.—Ask a butcher for two fresh eyes. Remove any portions of fat and muscle that may be attached to the outer surfaces. Compare the transparent anterior part, the cornea, with the opaque posterior part, the sclerotic. Note the entrance of the optic nerve at the back.

Spread a damp cloth on a board and lay the eye upon it, on its side. With a sharp knife cut through the sclerotic carefully at a point about midway between the edge of the cornea and the optic nerve. Let the line of the cut be parallel with the edge of the cornea. Enlarge the opening with blunt scissors. With care the sclerotic can be cut without injuring the delicate inner coats. Next cut through the choroid and the retina, and expose the clear glistening vitreous humor beneath. Note and compare the color, thickness, and texture of the sclerotic, the choroid, and the retina. Squeeze the eyeball gently and expel the vitreous humor. The lens may be expelled with the vitreous humor or it may remain behind. If it remains behind, remove it with the finger. Place the lens on a printed page and look through it at the letters. Note its shape. Examine the interior surface of the eyeball after the vitreous humor has been expelled. Note the entrance of the optic nerve, and also the blood tubes at the back, and a dark curtain, the iris, with its central hole, the pupil, in the front.

Take the other eye, and with a sharp knife cut through the cornea near its junction with the sclerotic. A small amount of

fluid, the aqueous humor, will escape. Compare it with the vitreous humor. Extend the cut all the way around the edge of the cornea so as to remove it. Compare the cornea with the sclerotic. Examine the iris from the front. With a pin, or thin splinter of wood, lift up the edge of the iris. Note its color and thickness. If the eyeball is squeezed firmly, the lens and the vitreous humor may be expelled through the opening in front.

EMERGENCIES

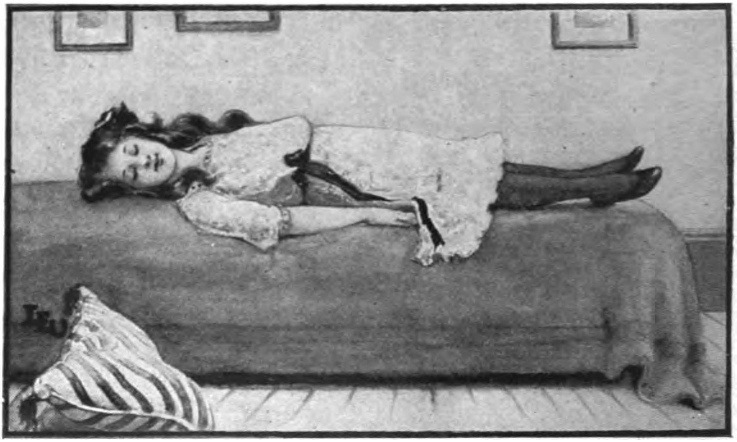
WHAT TO DO BEFORE THE DOCTOR COMES

Accidents happen constantly. Every day some one is cut, or burned, or swallows poison by mistake, or falls and is badly hurt. As it is not always possible to secure the services of a physician immediately in such emergencies, every one should learn how to give aid to the injured.

Burns or Scalds.—The clothing should be removed with great care, so as not to cause an increase of pain or to disturb the injured parts. The pain may be relieved by covering the burned part with cloth that has been wet with a warm solution of common baking soda. Apply glycerine, vaseline, lard or flour to cover the burned surface and protect it from the air. Do not put cold water on a burn. Everything applied to a burn or scald, or to any wounded surface, should be perfectly clean.

Clothes on fire.—Very serious injuries are caused by burning clothing. If anybody's clothing catches fire, wrap tightly

about him a coverlet, coat, blanket, shawl, rug, table cover, or something of the kind that can be had, so as to smother the flames. If nothing suitable for wrapping is at hand, have him



THE POSITION FOR A PERSON WHO HAS FAINTED

sit or roll on the floor, so as to cover the burning garments with his body, and try to smother the flames in that way.

The person whose clothes are on fire should never run—running only makes the fire burn more quickly.

To avoid swallowing flame when the clothing is on fire, one should cover the mouth and nose with the arm and lie down on the floor.

Fainting.—A person who has fainted should be placed flat on the side or back, with the head as low as the rest of the body, or even a little lower. If the body is in this position, blood will

flow to the head, and the faintness will pass off in a few minutes. Always allow plenty of fresh air.

Smelling-salts or camphor may be placed under the nose, but are not often required.

Do not dash cold water on a fainting person. Moisten the face with a wet cloth, or apply to the forehead a cloth wet with cold water. Do not force anything down the throat of a person who is unconscious, for he may in this way be choked to death.

Fits or convulsions.—Place the patient in a comfortable position on the side or back, loosen the clothing so as to allow easy breathing, and then avoid moving or disturbing him. If the face is red, place the head on a pillow; if it is pale, let the head be low.

Suffocation.—Suffocation is frequently caused by coal gas from a furnace or stove, by gas used for lighting houses, by gas at the bottom of old wells or in coal mines, and by the fumes of burning charcoal.

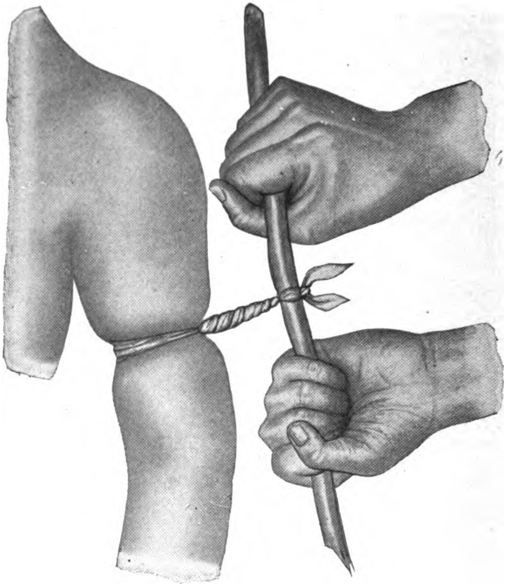
In a case of suffocation from any cause, remove the patient at once to the open air, loosen all tight clothing that hinders breathing, and moisten the face and chest with cold water.

Sunstroke.—Remove the patient at once to a cool place, and rub the body with ice, or apply plenty of cold water.

Frostbite.—Rub the frozen part with snow or cold water, then wrap it in a wet cloth. The frozen part should never be warmed quickly, but always slowly.

Sting of bees, wasps, and other insects.—Remove the sting, if it is left in the wound, and apply ammonia water, a solution of baking soda, or a little wet clay.

Snake bites.—If the bite is on the hand or leg, tie a handkerchief or stout cord loosely round the limb above the wound and twist it tightly with a stick, to prevent the poison from being carried upward to the rest of the body. Some one should suck



TO TREAT SNAKE BITE

the wound as quickly as possible, spitting out what is thus taken from the wound. There is no danger in doing this if there are no sores in the mouth.

Dog bites.—If the bite was made by a healthy dog, wash the wound with clean cold or hot water, and then apply a pad wet

with water. If the dog is known to be mad, treat the bite in the same way as a snake bite.

Cramps.—Sudden, sharp pains in the abdomen are often caused by eating unripe fruit, vegetables, or other indigestible food. Give castor oil, and apply cloths soaked in hot water, or a bottle of hot water, to the abdomen. If these measures fail to give relief in a short time, send for a physician.

Bleeding.—The quickest and safest way to stop bleeding from a wound of any kind is to place a finger or thumb directly upon the spot that bleeds.

Moderate pressure on the bleeding spot will stop the bleeding at once, whether the blood comes from an artery, from a vein, or from capillaries.

Keep the finger applied to the wound for ten or fifteen minutes and then remove it slowly.

If the bleeding begins again, apply the finger once more, and continue the pressure until medical aid can be secured.

Another way to stop the bleeding of a limb is by the use of a tourniquet. To make a tourniquet, first tie a knot in the centre of a handkerchief or a piece of cloth. Place this knot just above the bleeding point, and tie the ends of the handkerchief about the wounded limb. Put a stick inside the knot that ties the ends and twist hard to get pressure on the blood tube that is bleeding.

Nose-bleed.—Press firmly on the side of the nose from which the blood comes, so as to close the bleeding nostril completely. At the same time incline the head slightly forward, to keep the

blood from running down behind into the throat. If blood comes from both nostrils, close them both by pressing firmly on both sides.

If this plan fails, the nostril may be plugged with cotton, or with a plug made from a narrow strip torn from a clean handkerchief or other garment. The strip may be dipped into ice water or alum-water, if either is at hand.

Remove the plug gently after five or six hours.

If the bleeding begins again, put in another plug and send for a physician.

Be careful to avoid blowing the nose for some time after the bleeding stops.

Foreign bodies in the nose.—If a foreign body, such as a pea or a bean, gets into the nostril, blowing the nose may remove it, or it may be hooked out with a looped wire or a hairpin.

If the first efforts at removal are not successful, leave it alone and send at once for a physician.

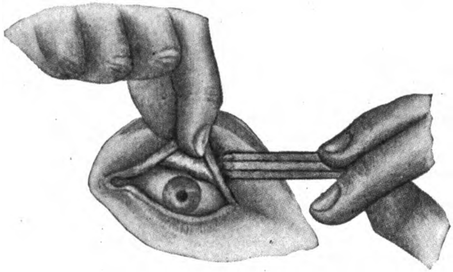
Foreign bodies in the ear.—Foreign bodies sometimes get into the ear. Insects occasionally crawl into it and cause great pain. The delicate drum membrane may be injured unless great care is used in removing such bodies. It is therefore much safer to have them removed by a doctor.

Foreign bodies in the eye.—A cinder or a bit of dust on the inner surface of the eyelid or on the surface of the eyeball may be wiped off easily with the corner of a clean handkerchief, or be washed out by bathing the eye. If these simple measures are not successful, obtain the aid of a physician without delay.

Foreign bodies in the throat.—Small pieces of food, bones or other foreign matter may become lodged in the throat and cause choking. If they are not coughed out quickly, they can often be removed with the first finger.

A few smart slaps on the back between the shoulders, while the body is bent forward, will often give instant relief.

Such foreign bodies as coins, pins, bones, and a great variety of similar things are sometimes swallowed accidentally.



REMOVING A FOREIGN BODY FROM THE EYELID

In such cases it is not wise to give purgatives, nor is it wise to cause vomiting. Give quantities of mashed potatoes and pancakes, and withhold all other food for a day or two. The foreign bodies become coated over, if such foods as these are given, and pass along the intestine in the natural way without doing harm.

Broken bones.—A broken bone should be kept as still as possible. If it is moved about, the broken ends, which are usually sharp and jagged, may injure the surrounding soft parts.

A patient with a broken bone should not be moved, if he can be made comfortable where he is until the doctor comes. The injured limb should be supported on a pillow, or anything soft, and kept in the position in which it is most comfortable.

Whenever it is necessary to move the patient before the doctor comes, it is best to use some form of temporary support to keep the broken bone steady and prevent further injury.

THE DEMI-GAUNTLET BANDAGE (DORSAL)
From "A Treatise on Surgery" by George Ryerson Fowler, M.D.

In the fractures of the arm or collar bone, a sling gives all the support that is required. If the bone that extends from the elbow to the shoulder be fractured, the sling should support the

hand and wrist only. If the collar bone or the bones that extend from the elbow to the wrist be fractured, the sling should be wide enough to support the whole of the arm below the elbow.

Splints are required when the bones of the leg are broken. A thin strip of board, a walking-cane, an umbrella, or any

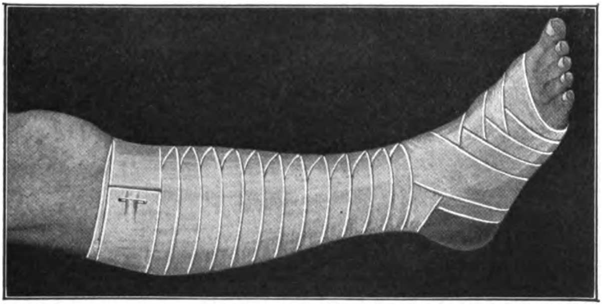


FIGURE-OF-8 OF LEG
From "A Treatise on Surgery" by George Ryerson Fowler, M.D.

straight stick may be used. Two splints should be employed. One should be placed on the outer side of the leg and the other on the inner side. The splints should be padded to prevent pain from pressure. They may be padded with cotton, pieces of cloth, moss, grass, or any soft material at hand; and they should be held in place by bandages, handkerchiefs, straps, cords, or by strips of cloth of any kind.

Poisoning.—A physician should be sent for without delay whenever poisoning is suspected, but do not wait for the physician to come before trying to relieve the patient.

In most cases of poisoning, the first thing to do is to make the

patient vomit, and thus expel the poison from the stomach. The exceptions to this rule are where strong acids or alkalis have been swallowed.

In order to produce vomiting, give large quantities of warm soap suds, or a mixture of mustard and water, in the proportion of a tablespoonful of mustard to a pint of water, or salt and water, in the proportion of two tablespoonfuls of salt to a glass of water. If none of these can be had quickly, give large draughts of warm water.

One or two cupfuls of any one of these simple emetics should be swallowed instantly. Then vomiting may be excited by putting a finger down the throat or by tickling the back part of the throat with a feather. As soon as the first attempt at vomiting is over, more water, soap suds, mustard and water, or salt and water, should be given, and vomiting should be excited again.

Repeat this several times in order to be sure that all the poison is washed out of the stomach.

Send, in the meantime, for the proper antidote for the poison that has been taken, and give it without delay. The following is a list of common poisons with their antidotes:

Sulphuric acid or oil of vitriol.—Give, in a teacup of water, two or three tablespoonfuls of any of the following: baking soda, magnesia, chalk, whiting, or plaster from a wall. Do not induce vomiting.

Oxalic acid, or salts of lemon.—Give, in a teacup of water, two or three tablespoonfuls of chalk, magnesia, whiting, lime, or plaster scraped from a wall. Do not induce vomiting.

Carbolic acid.—Give two or three glasses of milk, followed by two or three tablespoonfuls of sweet oil or castor oil. Do not induce vomiting.

Ammonia or hartshorn.—Give four tablespoonfuls of vinegar in a teacup of water, or give lemon juice or orange juice, followed by two tablespoonfuls of sweet oil. Do not induce vomiting.

Alcohol.—Try to induce vomiting. Give strong coffee, and apply cold water to the head.

Arsenic or Paris green.—Try to induce vomiting. Give three or four tablespoonfuls of magnesia in a teacup of water, or give castor oil, sweet oil, lime-water, raw eggs and milk. Get dialized iron from a drug store. Directions for its use accompany the preparation.

Copper or blue vitriol.—Try to induce vomiting. Give white of eggs and milk.

Lead, sugar of lead.—Try to induce vomiting. Give white of eggs and flaxseed tea.

Mercury, bichloride of mercury or corrosive sublimate.—Try to induce vomiting. Give milk, white of eggs, and flour in water.

Opium, or the following drugs which are made from opium or contain opium: *morphine, laudanum, paregoric, Dover's powder, Godfrey's cordial, soothing syrups.*—Make the patient vomit, and keep him awake by tapping him on the forehead with the finger nails, or by striking his face with the end of a wet towel. Be very careful not to allow him to become cold. Keep him on his feet. Do not let him lie down or sit down.

Phosphorus, used in making matches and in rat poison.—Try to induce vomiting. Give two or three tablespoonfuls of magnesia or chalk in a teacup of water. Avoid giving oil or fat.

Turpentine.—Try to induce vomiting. Give two tablespoonfuls of Epsom salts in half a teacup of water, and large quantities of flaxseed tea.

Toadstools and poisonous berries.—Try to induce vomiting. Give two tablespoonfuls of Epsom salts in half a teacup of water, and castor oil.

How to avoid poisoning accidents.—These unfortunate accidents would scarcely ever occur if all bottles and packages containing poison were kept by themselves in a suitable place. A bottle of carbolic acid or liniment, for example, should never be placed on a shelf beside a bottle of medicine that is intended for internal use. It is dangerously easy, especially at night, to mistake one for the other.

Keep all poisons locked up in a place set apart especially for them.

A label, with the name of the contents plainly marked on it, should be put on every bottle or package, whether it contains poison or not. If the label is lost, throw away the contents of the package or bottle. One mistake may cost many times the value of what is thrown away.

What to do in a case of drowning.—In a case of drowning, the first thing to do is to get the body out of the water. Unless the weather is severe, do not wait to carry the patient to a place

of shelter, but try at once to revive him. There are two things that you want to do—restore breathing, and get the body warm. Loosen the clothing about the neck and chest, and turn the

ARTIFICIAL EXPIRATION

body face down. Then wipe out the mouth and throat with your finger, covered with a clean cloth, or handkerchief.

While the body is face downward place your hands under the abdomen, and raise the body until the forehead just rests on the ground, so that the water in the mouth and throat may run out.

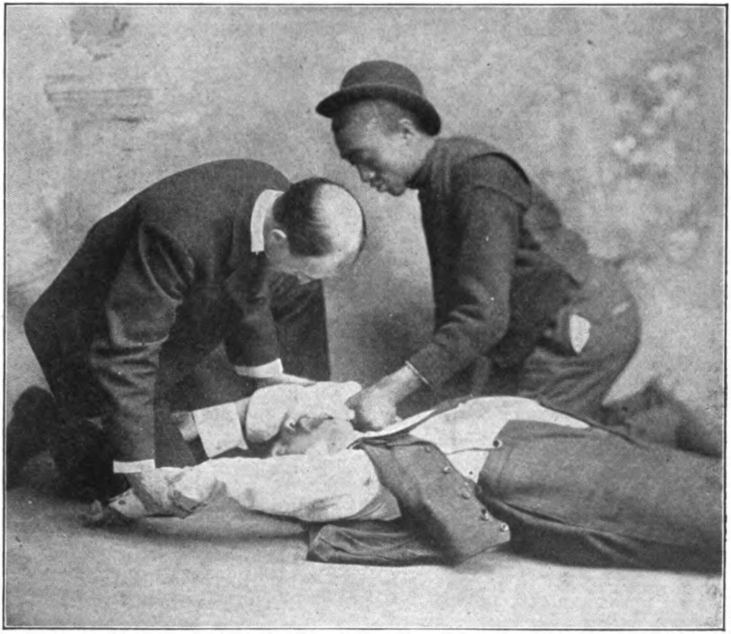
Then turn the body on its back, and place a roll of clothing, or something else a few inches high, under the shoulders so as to raise the chest. This straightens out the neck, and holds the chin away from the chest.

As the patient lies on his back insensible, the tongue is apt to fall back into the throat, and close the air-passage which leads from the mouth to the lungs. The tongue, therefore, should be carefully drawn well forward, out of the mouth, and held in that position, to allow the free passage of air to the lungs. It can be held more easily if a handkerchief or cloth is used, as in the picture.

Artificial breathing can then be produced by movements which cause the chest to become alternately larger and smaller, as in natural breathing. One of the best ways of doing this is by Sylvester's method.

Have some one kneel behind the head of the patient, and grasp his arms just below the elbow, then swing them around from the body until they are parallel with the head. This movement causes the chest to become larger. The lungs expand, and air goes in to fill them as in natural inspiration. After a slight pause, bring the arms back to their first position beside the body, and press firmly against the lower ribs. This movement lessens the size of the chest and forces air out of the lungs, as in natural expiration. The movements should be repeated about sixteen times a minute, and should be kept up either until natural breathing is restored, or until a physician declares that the heart has ceased to beat.

Since recovery sometimes takes place after artificial breathing has been kept up for two or three hours, do not be easily discouraged. Natural breathing commences feebly, and it should



ARTIFICIAL INSPIRATION

be aided as much as possible by swinging the arms back at the time of natural inspiration, and bringing them down to the sides at the time of natural expiration, until the breathing becomes strong.

Natural breathing may be stimulated by holding smelling

salts or hartshorn near the nose, but strong hartshorn should not be held too close, as it may cause injury to the inside of the nose.

Besides working to restore natural breathing, try in every possible way to get the body warm. Have the clothing removed as soon as possible, and the body dried gently. Cover it with any dry blankets, shawls, or clothing that can be obtained. Place along the sides of the trunk and limbs any hot stones, bricks, boards or sand that have been heated by the sun, or any hot water bottles, or other objects that can be secured. Have the limbs and trunk rubbed gently but firmly toward the chest, so as to produce warmth, and also to aid the blood in its return to the heart. As soon as the patient can swallow, give him frequently hot drinks, such as tea, coffee, or even water. He may also be given, as a stimulant, half a teaspoonful of aromatic spirits of ammonia in a tablespoonful of water, every half hour, till the feet and hands become warm, and the patient feels comfortable. When he feels well enough to be removed, he should be carried carefully, with head low, and put into a warm bed. Some one should remain with him for a while so that prompt measures may be taken if breathing should again stop.

HINTS FOR THE SICK-ROOM

Choice of the sick-room.—The sick-room should be the brightest and most cheerful room in the house. Fresh air, sunshine, and freedom from noise are the most important points to consider in making selection of a room. Choose a large,

well ventilated room into which the sun shines. If possible, it should have two windows, one facing the south. An open fireplace is always desirable in a sick-room, because it allows a constant current of fresh air to enter and foul air to escape.

Preparation of the sick-room.—The sick-room should contain no unnecessary articles of furniture. Two chairs, one or two small tables, and a comfortable bed for the patient are usually sufficient. Remove all heavy drapery and thick curtains from the windows, for they obstruct the free entrance of air and shut out the sunlight.

In contagious diseases, such as diphtheria, measles and scarlet fever, the carpets should be taken up and articles of clothing should not be allowed to remain in the sick-room. A few pictures may be left on the walls, as they are restful to the eye and give the room a cheerful appearance.

Care of the sick-room.—The sick-room should be kept clean and tidy. Offensive matters should not be allowed to remain in the room, but should be removed promptly. Never allow soiled clothing or bed-linen to accumulate, but remove them from the room as soon as they are changed.

Fresh flowers always make a room look cheerful, but care should be taken to select those having an odor that is not unpleasant to the patient.

It is often difficult to keep the air in a sick-room pure, and at the same time to avoid a draft. In summer the windows may be left open day and night. Excessive currents of air may be

avoided by means of screens placed between the patient and the windows. In winter, the lower sash of the window may be raised four or six inches, and the space under it may be closed with a board. Air will then pass in between the upper end of the lower sash and the lower end of the upper sash.

It should always be remembered that it is as important to have fresh air in winter as it is in summer, and that it is even more important to have a plentiful supply of fresh air during the night than during the day, because air at night is made impure also by lamps or gaslight. The air is usually colder during the night than during the day, but in other respects night air is practically the same as day air.

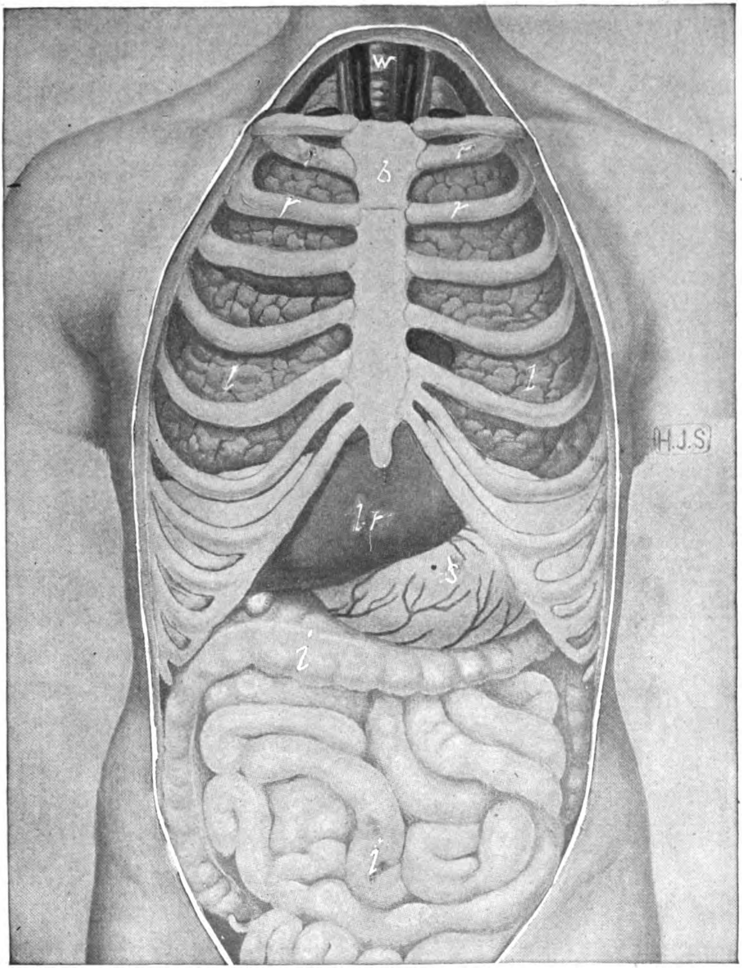
Care of the patient.—It is always desirable that one person should have entire charge of the sick-room, and should undertake the responsibility of carrying out the physician's orders. A good nurse will follow faithfully the directions given by the physician. The directions regarding food, treatment, and medicine should be written down in order that they may be carried out punctually and that mistakes may be avoided.

The person in charge of the sick-room should have regular hours for rest, meals, and exercise out-of-doors, for no nurse can do her work well and be cheerful when she is overtired. During her absence written orders should be left for those in attendance so as to prevent mistakes.

The comfort of the patient depends much upon the nursing. The work in the sick-room should be done quietly and cheerfully, without undue haste or excitement. The nurse should

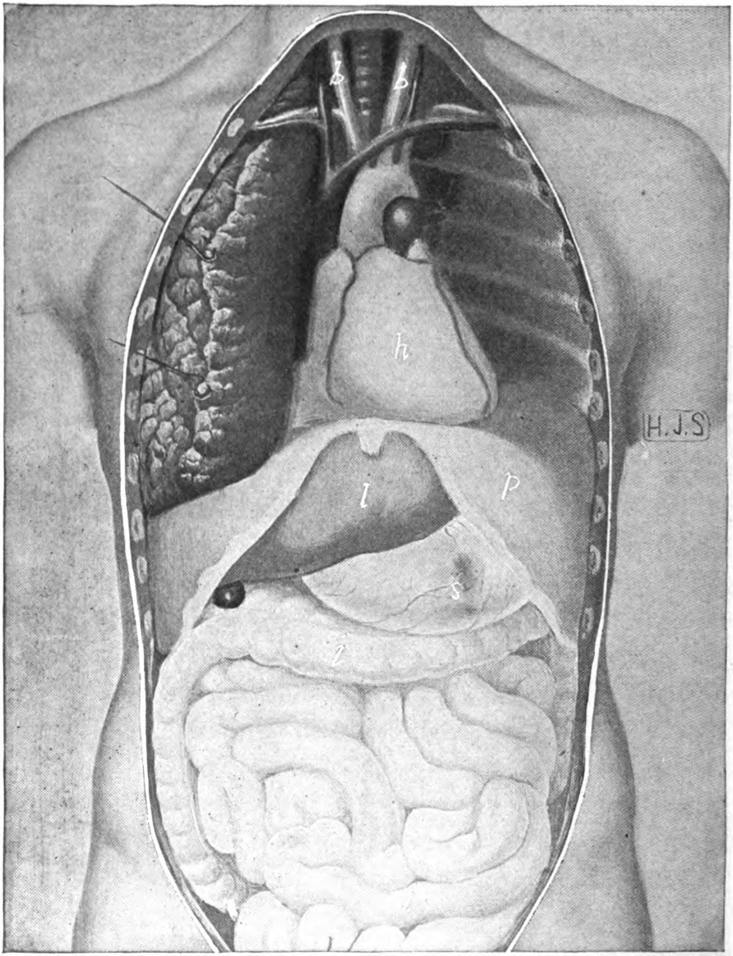
avoid talking too much, and should never weary the patient by describing her own trifling ailments and troubles.

A kind, sympathetic tone, gentleness in touch and movements, and a mind that is quick to appreciate the needs of the patient are qualities that are always highly prized in a nurse.



KEY TO THE PICTURE ON PAGE 8.

***w*, windpipe ; *b*, breastbone ; *r*, ribs ; *l*, lungs ; *lr*, liver ; *s*, stomach ; *i*, intestine.**



KEY TO THE PICTURE ON PAGE 9.

***b*, blood tubes ; *h*, heart ; *p*, partition between chest and abdomen ; *l*, liver ; *s*, stomach ; *i*, intestine.**

GLOSSARY

Ab-do'men.—The lower part of the trunk.
Ab-sorp'tion.—The passing of food from the intestine into the blood tubes
Ad'en-oid growths.—Small growths at the back of the nasal passages.
Al-bu'men.—A kind of proteid, as white of egg.
Al-i-men'ta-ry ca-nal'.—The tube in which food is received and digested.
A-mœ'ba.—One of the simplest animals known.
An-ti-sep'tic.—Anything that restricts the growth of germs.
A-or'ta.—The great artery that starts from the left side of the heart.
A'que-ous hu'mor.—A watery substance in the front part of the eyeball.
Ar'ter-y.—A blood tube through which blood flows away from the heart.
Asth'ma.—A disease that causes difficult breathing.
Au'ri-cle.—A chamber of the heart that receives blood from the veins.

Bac-te'ri-a.—Microscopic plants. Some of them cause diseases.
Brain.—The central organ of the nervous system.

Cap'il-la-ries.—Very small blood tubes that connect the arteries and the veins.
Car-bo-hy'drates.—Another name for starch and sugar.
Car'bon-di-ox'ide.—A colorless gas formed by respiration and also by fermentation.
Car'di-ac o'pen-ing.—The opening from the esophagus into the stomach.
Car'ti-lage.—Gristle.
Ca'se-in.—A proteid found in milk, from which cheese is made.
Cells.—The microscopic parts of living matter, of which the whole body is formed.
Cel'lu-lose.—The chief substance in the wall of vegetable cells.
Cer-e-bel'lum.—The lower and back part of the brain.
Cer'e-brum.—The upper and front part of the brain.
Cho'roid.—The middle coat of the eyeball.
Chyle.—A milky fluid in the lacteal tubes and the thoracic duct.
Chyme.—The soup-like contents of the stomach and intestine.

Cir-cu-la′tion.—The movement of blood through the blood tubes.
Clav′i-cle.—The collar bone.
Co-ag-u-la′tion.—A change from a liquid to semi-solid state; a curdling.
Con-ta′gious di-seas′es.—Diseases that one may take from another.
Cor′ne-a.—The transparent coat at the front of the eyeball.
Cor′pus-cles.—Minute cells in the blood.
Cra′ni-al nerves.—Nerves connected with the brain.
Cra′ni-um.—The part of the skull that holds the brain.

Der′mis.—The inner layer of the skin.
Di′a-phragm.—The muscular partition between the thorax and the abdomen.
Dis-in-fec′tant.—A substance that destroys germs.
Dis-lo-ca′tion.—The wrenching of bones out of position at a joint.

Ear drum.—A thin membrane that separates the external from the middle ear.
E-mul′sion.—A milk-like preparation of oil and water.
Ep-i-der′mis.—The outer part of the skin.
Ep-i-glot′tis.—A small lid that covers the opening into the windpipe.
Ep-i-the′li-um.—A layer of cells covering internal and external surfaces of the body.
E-soph′a-gus.—The tube through which food passes from the mouth to the stomach.
Eu-sta′chi-an tube.—A small tube that extends from the throat to the middle ear.
Ex-cre′tions.—Waste matters.
Ex-pi-ra′tion.—The act of breathing out air from the lungs.

Fer-men-ta′tion.—The process by which one substance is changed into another by ferments.
Fil′ter.—A strainer for removing impurities from water.
Func′tion.—The special work of an organ or part of the body.

Gang′li-on.—A small cluster of nerve-cells.
Gas′tric juice.—A thin, acid fluid made from the blood by the glands of the stomach.
Glot′tis.—The opening from the throat into the windpipe.
Glu′ten.—A proteid found in wheat and some other grains.

Hair fol′li-cle.—A little pit in the skin in which the root of the hair grows.
Ha-ver′sian ca-nals′.—Channels in bone substance for small blood tubes.
Hu′mer-us.—The bone between the shoulder and the elbow.
Hy′dro-gen.—A colorless gas forming, by volume, two-thirds of water.

In-spi-ra′tion.—The act of breathing air into the lungs.
In-tes′tine.—The part of the alimentary canal that is below the stomach.
I′ris.—A thin colored curtain in the front part of the eye.
Ir-ri-ta-bil′i-ty.—The power of responding to a stimulus.
Is-o-la′tion.—Separation.

Kid′neys.—The organs that take urine from the blood.

Lac′te-als.—Small tubes that carry fat from the intestine to the lymph tubes.
Lac′tic ac′id.—The acid formed when milk sours.
Lar′ynx, cr Ad′am's ap′ple.—The enlarged part of the windpipe. It is the organ of the voice.
Lig′a-ment.—A band of white connective tissue that joins bones together.
Liv′er.—The largest gland in the body, situated beneath the diaphragm on the right side of the body.
Lock′jaw, or Tet′a-nus.—A disease in which there is stiffness or spasm of muscles.

Mal′tose.—The kind of sugar that is made when saliva acts on starch.
Me-dul′la.—The lowest part of the brain.
Mem′brane.—A thin layer of tissue.
Mi′cro-or′gan-ism.—A body so small that we can see it only with a microscope.
Mu′cous mem′brane.—The thin covering lining the mouth, alimentary canal, and other cavities in the body that communicate with the air.
My′o-sin.—The kind of proteid contained in lean meat.

Nar-cot′ic.—A drug which, in small doses, produces sleep, and in large doses produces stupor or even death.
Nerve-cell.—The enlarged part of a nerve cell. It receives and sends out nerve impulses.
Nerve-fibres.—Fine thread-like projections that extend from the nerve-cells.
Nerves.—Long bundles of nerve-fibres which carry messages to different parts of the body.

Nic′o-tine.—A poison contained in the leaves of tobacco.
Ni′tro-gen.—A colorless gas forming about 79 per cent. of air.
Ni-trog′en-ous food.—Food that contains nitrogen.
Nu′cle-us.—A small body within the protoplasm of the cell.
Nu-tri′tion.—The process by which the body is nourished by food.

Or′gan.—A part of the body that has a special work, or function.
Ox-i-da′tion.—The uniting of some substance with oxygen.
Ox′y-gen.—A colorless gas forming about 21 per cent. of air.

Pan′cre-as.—A gland behind the stomach.
Pa-pil′la.—A small elevation of the true skin.
Par′a-sites.—Animals or plants that procure nourishment from, and live on, other animals or plants.
Par-ot′id glands.—The salivary glands that lie in front of the ears.
Pas-teur′ize.—To destroy germs in milk by heating it until it reaches a temperature of about 150° F.
Pa-tel′la.—The kneecap.
Pel′vis.—A bony ring that supports the spine and rests upon the thigh bones.
Pep′sin.—A ferment contained in gastric juice.
Per-i-car′di-um.—The sac surrounding the heart.
Per-i-os′te-um.—A dense membrane covering the whole surface of bone.
Per-i-stal′tic move′ments.—Movements caused by the contraction of muscles in the stomach and intestine.
Phar′ynx.—The part of the alimentary canal between the mouth and the esophagus.
Phys-i-ol′o-gy.—The study of the functions performed in living things.
Plas′ma.—The watery part of the blood.
Pleu′ra.—A serous membrane covering the lungs.
Pneu-mo′ni-a.—A disease in which there is inflammation of the lungs.
Por′tal cir-cu-la′tion.—The movement of blood through the liver.
Pro′te id.—A food used for the building of body tissue.
Pro′to plasm.—The principal substance in an animal or a vegetable cell.
Pty′a-lin.—The ferment in saliva.
Pulse.—The throb of arteries as blood is forced through them by the heart.
Pu′pil.—The small hole in the iris, through which light enters the eye.
Py-lo′rus.—The opening from the stomach to the intestine.
Pyr′e-thrum.—A plant from whose flowers insect powder is made.

Re-flex′ ac′tion.—An action that is involuntary.
Ren′net.—A ferment that is secreted by the stomach. It curdles milk.
Ret′i-na.—The inner coat of the eyeball.
Rheu′ma-tism.—An acute disease that causes pain in the joints or muscles.

Sa-li′va.—The digestive fluid secreted by the salivary glands.
Scap′u-la.—The shoulder blade.
Scle-rot′ic.—The white, outer coat at the back of the eyeball.
Se′rous mem′brane.—A membrane lining a cavity of the body from which there is no outlet to the surface.
Sew′age.—Liquid waste matter.
Skel′e-ton.—The bony framework of the body.
Skull.—The bony box that covers and protects the brain.
Spi′nal col′umn.—The backbone.
Spi′nal cord.—The part of the nervous system that extends down within the backbone.
Spore.—A spore corresponds to a seed in other plants.
Sprain.—A straining or twisting of the ligaments of a joint.
Ster′num.—The breast bone.
Stom′ach.—A muscular sac, or enlargement of the alimentary canal, in which digestion is carried on.
Sub-lin′gual glands.—The salivary glands beneath the tongue.
Sym-pa-thet′ic nerves.—Nerves that carry impulses to involuntary muscles.
Syn-o′vi-a.—A fluid that lubricates the movable joints.
Sys-tem′ic cir-cu-la′tion.—The movement of the blood through all the body except the lungs.

Ten′don.—A strong cord or band of connective tissue to which the end of a muscle is attached.
Tho-rac′ic duct.—A tube in front of the spine that conveys lymph to veins leading to the heart.
Tho′rax.—The chest.
Tis′sue.—One of the kinds of material that make up an organ.
Tra-che′a.—The windpipe.
Tu-ber-cu-lo′sis.—A germ disease that may affect any part of the body.

U-re′a.—The chief waste product of proteid. It is excreted in the urine.

Ve′nous blood.—The dark blood in the veins.

Ven-ti-la'tion.—The process of removing impure air and supplying fresh air.

Ven'tri-cle.—A chamber of the heart that receives blood from an auricle.

Ver'mi-form ap-pen'dix.—A worm-like projection that hangs down from the large intestine.

Ver'te-bra.—One of the bones that make up the backbone.

Vil'li.—Hair-like projections from the inner surface of the small intestine.

Vit're-ous hu'mor.—A thick glassy substance inside the eyeball.

Wind'pipe.—The tube extending from the throat to the lungs.

Yeast.—The agent causing fermentation that produces alcohol from sugar.

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